



GEOTECHNICAL INVESTIGATION

**KINGWOOD WATER PLANT #3
GROUND STORAGE TANK #2
8750 MILLS BRANCH DRIVE
WBS NO. S-000600-0044-4
HOUSTON, TEXAS**

**Reported to
IDS Engineering Group
Houston, Texas**

by

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REPORT NO. G149-13R1

September 2014



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September 15, 2014

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**Reference: Revised Geotechnical Investigation
Kingwood Water Plant #3, GST #2
WBS No.: S-000600-0044-4
Houston, Texas
AEC Report No. G149-13R1**

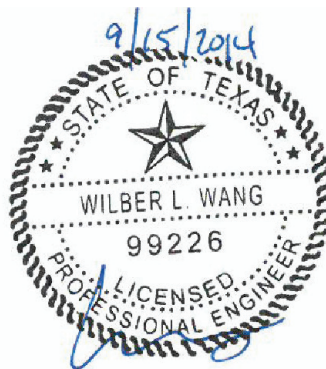
Dear Mr. Wallick,

Aviles Engineering Corporation (AEC) is pleased to present this revised report of our geotechnical investigation for the above referenced project. This investigation was authorized on September 9, 2013 by Mr. Paul Wallick, P.E., Senior Project Manager of IDS, based upon AEC Proposal No. G2013-08-02, dated August 2, 2013. This revised report will supersede AEC's previously submitted report for the referenced project (dated January 10, 2014).

AEC appreciates the opportunity to be of service to you. Please call us if you have any questions or comments concerning this report or when we can be of further assistance.

Respectfully submitted,
Aviles Engineering Corporation
(TBPE Firm Registration No. F-42)

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Reports Submitted: 1 IDS Engineering Group
1 File (electronic)

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EXECUTIVE SUMMARY

This report presents the results of a geotechnical investigation performed by Aviles Engineering Corporation (AEC) for a proposed 1.27 million gallon ground storage tank (GST) at the City of Houston's Kingwood No. 3 Water Plant. The water plant is located at 8750 Mills Branch Road, in Houston, Texas (Houston/Harris County Key Map No.: 297V). Based on information provided by IDS Engineering Group (IDS), the proposed GST will have a diameter of 95 feet and will be 24 feet high. The new tank (GST #2) will be located to the east of an existing 110 foot diameter by 24 foot high tank (GST #1) at the site.

Our findings and recommendations are summarized below:

- Based on Borings B-1 through B-4, B-6, and B-7, subsurface soil conditions within the tank footprint generally consist of 4 to 8 feet of stiff to hard sandy lean clay (CL) and silty clay (CL-ML) fill material at the ground surface, underlain by approximately 10 to 13 feet of stiff to hard lean/fat clay (CL/CH), followed by approximately 4 to 20 feet of medium dense to very dense silty/clayey sand (SM/SC/SC-SM), then by approximately 16 to 23 feet of firm to very stiff lean/fat clay (CL/CH), then by approximately 13 to 32 feet of very loose to very dense silty/clayey sand (SM/SC) to the boring termination depths.
- Details of the soils encountered during drilling are presented on the boring logs. The cohesive soils encountered in the borings have Liquid Limits (LL) ranging from 22 to 80 and Plasticity Indices (PI) ranging from 6 to 60. This indicates that the cohesive soils have slight to very high expansive potential. The cohesive soils encountered are classified as "CL-ML", "CL", and "CH" type soils and the granular soils are classified as "SP-SM", "SC", "SM", "SC-SM" type soils in accordance with ASTM D 2487.
- Groundwater was encountered in the borings at a depth of 20 to 28 feet during drilling and subsequently rose to a depth of 16.0 to 24.2 feet after the initial encounter. This indicates that the groundwater at the site could be pressurized.
- Recommendations for the tank foundation ring wall are presented in Section 5.1 of this report. Based on the borings, AEC recommends that the GST be supported on a ring wall foundation founded at 4 feet below existing grade. AEC estimates that the new tank will experience approximately 6.1 inches of settlement at the tank center and approximately 3.7 inches of settlement at the tank perimeter.
- This Executive Summary provides an overview of the geotechnical investigation and should not be used without the full text of this report.



GEOTECHNICAL INVESTIGATION

**KINGWOOD WATER PLANT #3
GROUND STORAGE TANK #2
8750 MILLS BRANCH DRIVE
WBS NO. S-000600-0044-4
HOUSTON, TEXAS**

1.0 INTRODUCTION

1.1 Project Description

This report presents the results of a geotechnical investigation performed by Aviles Engineering Corporation (AEC) for a proposed 1.27 million gallon Ground Storage Tank (GST) at the City of Houston's (COH) Kingwood Water Plant No. 3. The water plant is located at 8750 Mills Branch Road, in Houston, Texas (Houston/Harris County Key Map No.: 297V). A vicinity map is presented on Plate A-1, in Appendix A. Based on information provided by IDS Engineering Group (IDS), the proposed GST will have a diameter of 95 feet and will be 24 feet high. The new tank (GST #2) will be located to the east of an existing 110 foot diameter by 24 foot high tank (GST #1) at the site. AEC understands that the new GST will be supported with a ring wall foundation.

1.2 Purpose and Scope

The purpose of this geotechnical investigation is to evaluate the subsurface soil and ground water conditions at the project site and to develop geotechnical engineering recommendations for design and construction of the proposed GST. The scope of this geotechnical investigation is summarized below:

1. Drilling and sampling six soil borings to depths ranging from 40 to 80 feet below existing grade;
2. Performing soil laboratory testing on selected soil samples;
3. Engineering analysis and recommendations for the GST ring wall foundation, including allowable bearing capacity, tank settlement, and subgrade preparation; and
4. Construction recommendations for the GST foundation.

2.0 SUBSURFACE EXPLORATION

Subsurface conditions were initially investigated in August 2013 by drilling four soil borings (Borings B-1 through B-4) to depths ranging from 40 to 80 feet below existing grade within the footprint of the proposed tank. After reviewing AEC's findings, the COH's Geo-Environmental Services Branch requested that two additional



borings be performed by Associated Testing Laboratories, Inc. (ATL) at the tank location to confirm the soil and groundwater information presented in AEC's boring logs. Two borings (Borings B-5 and B-5A) were drilled to 60 feet deep by ATL in April 2014. After reviewing ATL's findings and based on discussions with COH, IDS authorized AEC to drill two additional 60 foot deep borings (Borings B-6 and B-7) in August 2014. AEC's Borings B-6 and B-7 were drilled within 5 to 8 feet of ATL's Borings B-5 and B-5A, respectively. AEC's boring locations are presented on the Boring Location Plan on Plate A-2, in Appendix A. For reference, ATL's boring location plan is presented on Plate B-1, in Appendix B. After completion of drilling, the borings were surveyed. Boring survey data is presented on the representative boring logs.

The borings were drilled using a truck-mounted drill rig. Borings were advanced initially by dry auger method, then using wet rotary method once the borings caved in or saturated granular soils were encountered. Undisturbed samples of cohesive soils were obtained from the borings by pushing 3-inch diameter thin-wall, seamless steel Shelby tube samplers in accordance with ASTM D 1587. Granular soils were sampled with a 2-inch split-barrel sampler in accordance with ASTM D 1586. Standard Penetration Test resistance (N) values were recorded for the granular soils as "Blows per Foot" and are shown on the boring logs. Strength of the cohesive soils was estimated in the field using a hand penetrometer. The undisturbed samples of cohesive soils were extruded mechanically from the core barrels in the field and wrapped in aluminum foil; all samples were sealed in plastic bags to reduce moisture loss and disturbance. The samples were then placed in core boxes and transported to the AEC laboratory for testing and further study. The borings were grouted with cement-bentonite using tremie pipe method upon completion of drilling. Details of the soils encountered in the borings are presented on Plates A-3 through A-9, in Appendix A.

3.0 LABORATORY TESTING

Soil laboratory testing was performed by AEC personnel. Samples from the borings were examined and classified in the laboratory by a technician under supervision of a geotechnical engineer. Laboratory tests were performed on selected soil samples in order to evaluate the engineering properties of the foundation soils in accordance with applicable ASTM Standards. Atterberg limits, moisture contents, sieve analysis, percent passing a No. 200 sieve, and dry unit weight tests were performed on representative samples to establish the index properties and confirm field classification of the subsurface soils. Strength properties of cohesive soils were estimated by means of Torvane (TV), Unconfined Compression (UC), and Unconsolidated-Undrained (UU) triaxial tests performed on undisturbed samples. The test results are presented on their representative boring logs. A key to the boring logs, classification of soils for engineering purposes, terms used on boring logs, and

reference ASTM Standards for laboratory testing are presented on Plates A-10 through A-13, in Appendix A. Sieve analysis results are presented on Plate A-14, in Appendix A.

Four one-dimensional consolidation tests were performed on selected soil samples in order to evaluate the general compressibility characteristics of the clayey soils at the proposed GST. The results of the consolidation tests are presented on Plates A-15 through A-18, in Appendix A. The initial void ratio, compression index, recompression index, preconsolidation pressure, and estimated overconsolidation ratio (OCR) for the consolidation tests are summarized in Table 1.

Table 1. Summary of Consolidation Test Results

Sample ID and Description	e_0	C_c	C_r	p_c (tsf)	OCR
B-1, 6'-8', Lean Clay (CL)	0.5575	0.1240	0.0160	2.9	6.3
B-1, 16'-18', Silty Clayey Sand (SC-SM)	0.6017	0.1530	0.0154	1.9	1.7
B-1, 33-35', Lean Clay w/Sand (CL)	0.4866	0.0544	0.0100	1.7	0.9
B-1, 43'-45', Lean Clay w/Sand (CL)	0.7105	0.1942	0.0164	1.1	0.5

Note: (1) e_0 = initial void ratio;
 (2) C_c = compression ratio;
 (3) C_r = recompression ratio, which is derived from the recompression curve within the stress range from 1 to 4 tsf;
 (4) p_c = preconsolidation pressure; and
 (5) OCR = overconsolidation ratio.

4.0 SITE CONDITIONS

Based on our site visit, the proposed tank area is basically flat and is covered with mowed grass. A shallow drainage swale is located along the north and east perimeter of the site.

4.1 Subsurface Conditions

Soil strata encountered in our borings are summarized below:

Boring	Depth	Description of Stratum
B-1	0' - 4'	Fill: stiff to hard, Lean Clay w/Sand (CL)
	4' - 16'	Stiff to very stiff, Lean Clay (CL), with slickensides
	16' - 23'	Very dense, Silty Clayey Sand (SC-SM), with sand seams
	23' - 30'	Medium dense, Clayey Sand (SC)
	30' - 48'	Stiff, Lean Clay w/Sand (CL), with silt partings and sand seams
	48' - 80'	Medium dense to very dense, Silty Sand (SM)

<u>Boring</u>	<u>Depth</u>	<u>Description of Stratum</u>
B-2	0' - 6'	Fill: stiff to very stiff, Lean Clay w/Sand (CL)
	6' - 18'	Very stiff to hard, Fat Clay (CH), with slickensides
	18' - 22'	Very dense, Silty Sand (SM)
	22' - 38'	Medium dense, Clayey Sand (SC), with vertical sand seams
	38' - 40'	Stiff to very stiff, Lean Clay (CL), with fat clay pockets
B-3	0' - 6'	Fill: hard, Sandy Lean Clay (CL)
	6' - 16'	Stiff to very stiff, Fat Clay (CH)
	16' - 18'	Sandy Silty Clay (CL-ML)
	18' - 23'	Dense, Silty Sand (SM)
	23' - 40'	Stiff to very stiff, Lean Clay (CL), with slickensides
B-4	0' - 8'	Fill: very stiff to hard, Silty Clay w/Sand (CL-ML)
	8' - 16'	Stiff to very stiff, Fat Clay (CH), with slickensides
	16' - 18'	Very stiff, Sandy Fat Clay (CH), with siltstone fragments
	18' - 22'	Medium dense, Silty Sand (SM)
	22' - 40'	Firm to very stiff, Lean Clay w/Sand (CL)
B-5/B-5A		Borings drilled by ATL. See Plates B-2 and B-3, in Appendix B.
B-6	0' - 4'	Fill: very stiff to hard, Sandy Lean Clay (CL), with silt partings and roots
	4' - 10'	Stiff to very stiff, Sandy Lean Clay (CL)
	10' - 15.5'	Very stiff, Fat Clay (CH)
	15.5' - 16.5'	Very stiff, Sandy Lean Clay (CL), with sand seams
	16.5' - 22'	Dense, Silty Sand (SM)
	22' - 32'	Stiff to very stiff, Fat Clay (CH), with slickensides
	32' - 41'	Firm to stiff, Lean Clay (CL), with silt partings
	41' - 47'	Loose, Clayey Sand (SC), interlayered with silty sand and sandy clay
	47' - 57'	Medium dense, Silty Sand (SM), with clay pockets
	57' - 60'	Firm, Lean Clay (CL), with clayey sand seams and silt partings
B-7	0' - 4'	Fill: hard, Sandy Lean Clay (CL), with partings and roots
	4' - 8'	Stiff, Lean Clay (CL), with silt partings and roots
	8' - 17'	Stiff to very stiff, Fat Clay (CH), with slickensides
	17' - 23'	Medium dense, Silty Sand (SM), with clayey sand pockets
	23' - 31'	Very stiff, Fat Clay (CH), with slickensides
	31' - 46'	Firm to very stiff, Lean Clay w/Sand (CL), with silt partings
	46' - 52'	Very loose, Clayey Sand (SC)
	52' - 57'	Dense, Poorly Graded Sand w/Silt (SP-SM), with clayey sand pockets, gravel, and organics
	57' - 60'	Medium dense, Lean Clay (CL), with silt partings, sand pockets, and gravel

Borings B-6 and B-7: As indicated in Section 2.0 of this report, Borings B-6 and B-7 were drilled to confirm ATL's Borings B-5 and B-5A; as a result, Borings B-6 and B-7 were drilled within 5 to 8 feet of ATL's Borings B-5 and B-5A, respectively. AEC notes that a 'very loose' Clayey Sand (SC) layer (SPT Blow Count of 2) was encountered at a depth of 46 to 52 feet in Boring B-7. However, when comparing Boring B-7 to Boring B-1,

AEC is not certain, but believes that the SPT blow count from 48 to 50 feet in Boring B-7 could be artificially low, potentially due to the proximity of Boring B-7 to ATL's borings, as well as possible disturbance from ATL's drilling. Disturbance in the 'very loose' sand layer could have been caused by improper drilling mud head pressure or from temporary loss of drilling mud circulation while drilling Borings B-5 and B-5A. This disruption of wet rotary drilling could have caused the borehole walls to collapse in the sand strata, causing saturated sand/silt to flow into the borehole, which would result in a loss of ground, which would then be encountered in Boring B-7 since it is adjacent to ATL's boring.

Soil Properties: Details of the soils encountered during drilling are presented on the boring logs. The cohesive soils encountered in our borings have Liquid Limits (LL) ranging from 22 to 80 and Plasticity Indices (PI) ranging from 6 to 60. This indicates that the cohesive soils have slight to very high expansive potential. The cohesive soils encountered are classified as "CL-ML", "CL", and "CH" type soils and the granular soils are classified as "SP-SM", "SC", "SM", "SC-SM" type soils in accordance with ASTM D 2487. "CH" soils can undergo significant volume changes due to seasonal changes in moisture contents. "CL" and "CL-ML" soils with lower LL (less than 40) and PI (less than 20) generally do not undergo significant volume changes with changes in moisture content. However, "CL" soils with LL approaching 50 and PI greater than 20 essentially behave as "CH" soils and could undergo significant volume changes. Slickensides were encountered in fat clay soil.

Groundwater: Groundwater was encountered in the borings at a depth of 20 to 28 feet during drilling and subsequently rose to a depth of 16.0 to 24.2 feet after the initial encounter. This indicates that the groundwater at the site could be pressurized. For the purposes of this investigation, AEC conservatively considered the boring cave-in depth as the equal to the groundwater depth. A summary of groundwater conditions encountered in the borings is presented on Table 2.

Table 2. Groundwater Depths below Existing Ground Surface

Boring No.	Date Drilled	Boring Depth (ft)	Groundwater Depth in Boring (ft)	Boring Cave-in Depth
B-1	8/23/13	80	24 (Initial) 23 (15 min.)	27 (Drilling) 16 (8/26/13)
B-2	8/27/13	40	22.5 (Drilling)*	22.5 (Drilling)
B-3	8/23/13	40	24 (Drilling)*	24 (Drilling)
B-4	8/27/13	40	20 (Drilling)*	20 (Drilling)
B-5/B-5A	Borings drilled by ATL, see Plates B-2 and B-3 in Appendix B			

Boring No.	Date Drilled	Boring Depth (ft)	Groundwater Depth in Boring (ft)	Boring Cave-in Depth
B-6	8/27/14	60	28 (Initial) 24.1 (15 min.) 7.6 (Complete)	25.8 (Drilling) 33.1 (Complete)
B-7	8/27/14	60	28 (Initial) 24.1 (15 min.) 11.1 (Complete)	24.3 (Drilling) 59.4 (Complete)

Note: (*) AEC conservatively assumes that the cave-in depth is equal to the groundwater level.

The information in this report summarizes conditions found on the dates the borings were drilled. However, it should be noted that our ground water observations are short term; ground water depths and subsurface soil moisture contents will vary with environmental variations such as frequency and magnitude of rainfall and the time of year when construction is in progress.

4.2 Subsurface Variations

It should be emphasized that: (i) at any given time, ground water depths can vary from location to location, and (ii) at any given location, ground water depths can change with time. Ground water depths will vary with seasonal rainfall and other climatic/environmental events. Subsurface conditions may vary in between and away from borings.

Clay soils in the Houston area typically have secondary features such as slickensides and contain sand/silt seams/lenses/layers/pockets. It should be noted that the information in the boring logs is based on 3-inch diameter soil samples which were generally obtained at intervals of 2 feet in the top 20 feet of the borings and at intervals of 5 feet thereafter to the boring termination depths. A detailed description of the soil secondary features may not have been obtained due to the small sample size and sampling interval between the samples. Therefore, while some of AEC's logs show the soil secondary features, it should not be assumed that the features are absent where not indicated on the logs.

5.0 ENGINEERING ANALYSIS AND RECOMMENDATIONS

Based on information provided by IDS, the proposed GST will have a diameter of 95 feet and will be 24 feet high. The new tank (GST #2) will be located to the east of an existing 110 foot diameter by 24 foot high tank (GST #1) at the site. The closest edge-to-edge distance between the existing and proposed tank is approximately 9 feet. AEC understands that the new GST will be supported with a ring wall foundation. According to IDS, the



existing tank was constructed in 1989 and has remained in service since it was built. The Finished Floor Elevation (FFE) of the new tank is at +67.1 feet Mean Sea Level (MSL). Based on the provided survey drawing, existing grade within the tank footprint varies from +65.88 to +66.48 feet MSL. The surface elevation of Borings B-1 through B-4 (which were performed within the footprint of the proposed tank) varies from elevation +66.22 to +66.58 feet MSL.

Based on our borings, there is approximately 4 to 8 feet of existing fill material at the ground surface within the proposed tank footprint. Based on these soil conditions, AEC recommends that the GST be supported on a ring wall foundation founded at a depth of 4 feet below existing grade.

5.1 1.27 Million Gallon Ground Storage Tank

5.1.1 Tank Ring Wall Foundation

A ring wall foundation at a depth of 4 feet below existing grade (bearing at an approximate elevation of +62.25 feet MSL) should be designed for an allowable net bearing capacity of 2,000 pounds per square foot (psf) for dead loads and 3,000 psf for total loads. A minimum factor of safety (FS) of 3 and 2 was applied for sustained loads and total loads, respectively; whichever bearing capacity is critical should be used for design.

Since the foundation will be subjected to hoop stresses, adequate reinforcement will be required to resist these forces. For the calculation of the lateral pressure on the ring wall foundation, at-rest earth pressure should be considered for design. The coefficient of earth pressure at-rest, $K_0 = 0.95$, can be used in the design. At-rest pressure, p_h (psf), inside the ring wall can be calculated as:

$$P_h = (p_0 + \gamma z) * K_0 \quad \text{.....Equation (1)}$$

where, p_0 = tank pressure at the finished grade elevation, psf;
 γ = wet unit weight of soil, 125 pcf;
 z = depth below finished grade, ft; and
 K_0 = coefficient of earth pressure at-rest, 0.95

Foundation Settlements: AEC calculated settlements based on the boring logs, soil laboratory testing results, and anticipated tank load. Considering a 24 foot high water head over a 95 foot diameter tank base, AEC estimated a tank load pressure of approximately 1,700 psf. Based on the estimated tank pressure, AEC estimated total

settlement (which includes both immediate and long-term settlements, respectively) at the center and edge of the tank. A summary of the tank settlements is presented on Table 3.

Table 3. Estimated Settlement of GST #2

Tank	Tank Height (ft)	δ_v (in)	S_{c1} (in)	S_{c2} (in)	Total S (in)
Center (Based on Boring B-1)	24	0.8	0.5	4.8	6.1
Edge (Based on Borings B-2, B-3, and B-4)		0.5	0.3	2.9	3.7

Note: (1) δ_v = immediate settlement, S_{c1} = Estimated settlement resulting from granular soils; S_{c2} = Estimated consolidation settlement resulting from clayey soils; Total settlement, $S = \delta_v + S_{c1} + S_{c2}$.

AEC anticipates that the settlement at the tank center due to the new tank load will be approximately 6 inches (as shown in Table 3). Note that the immediate settlement and settlement resulting from granular soils can be considered completed once the construction is completed and the tank is fully loaded.

Settlement Influence of Proposed Tank on Existing Tank: Since the closest edge to edge distance between the existing and proposed tank is approximately 9 feet, AEC estimated the settlement impact of the new tank on the existing tank perimeter. Assuming that the subsurface soils at the existing tank site is similar to that at the proposed tank area, AEC estimates that the existing tank could settle approximately 0.5 inches due to the impact of the new tank load. AEC also estimates that the existing tank will have a limited influence on the settlement of the proposed tank.

Time Rate of Consolidation Settlement: Time rate of foundation settlements is plotted as a curve of percent total consolidation settlement versus time for the GST on Plates A-19 and B-20, in Appendix A. The curve is based on the assumption of a one-month linear construction period, i.e. the foundation soils will be loaded linearly during construction.

Frequently, the predicted settlement time is longer than that observed in the field for the following reasons: (1) theoretical conditions assumed for the consolidation analysis do not hold in-situ because of intermediate lateral drainage, anisotropy in permeability, time dependency of real loading, and the variation of soil properties with effective stress; and (2) the coefficient of consolidation, as determined in the laboratory, decreases with sample disturbance; therefore, predicted settlement time tends to be greater than actual settlement time.

5.1.2 Tank Pad Preparation

Subgrade Preparation: Subgrade preparation should extend a minimum of 5 feet beyond the tank perimeter. A minimum of 6 inches of surface soils, existing vegetation, trees, roots, and other deleterious materials shall be removed and wasted in accordance with Section 02233 of the latest edition of the City of Houston Standard Construction Specifications (COHSCS). The excavation depth should be increased when inspection indicates the presence of weak, organics, and deleterious materials to greater depths.

After surface stripping, an additional 1.5 feet (total depth of 2 feet, which includes the 6 inches of surface removal) of existing soils should be removed. The exposed subgrade should be proof-rolled in accordance with Item 216 of the 2004 TxDOT Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges to identify and remove any weak, compressible, or other unsuitable materials; such materials should be replaced with compacted select fill or clean stabilized soils.

After proof rolling, compacted select fill or clean, stabilized soils should then be used to achieve the FFE of the tank. Select fill or stabilized soil should be in accordance with Section 5.2 of this report. We recommend that the final subgrade surface be crowned about 3 to 4 inches higher at the tank center than the edge, since the settlement at the tank center is typically higher than the tank edge. Considering the potential of differential settlements, we recommend the use of flexible connections between pipelines and the tank. We suggest that the tank foundation structural design consider the potential differential settlements and use stiffened panels if appropriate.

5.2 **Select Fill**

Select fill should consist of uniform, non-active inorganic lean clays with a PI between 10 and 20 percent, and more than 50 percent passing a No. 200 sieve. Excavated material delivered to the site for use as select fill shall not have clay clods with PI greater than 20, clay clods greater than 2 inches in diameter, or contain sands/silts with PI less than 10. Prior to construction, the Contractor should determine if he or she can obtain qualified select fill meeting the above select fill criteria.

As an alternative to imported fill, on-site soils excavated during construction can be stabilized with a minimum of 5 percent hydrated lime by dry soil weight. Lime stabilization shall be performed in accordance with Section 02336 of the latest edition of the COHSCS. AEC prefers using stabilized on-site clay as select fill since

compacted lime-stabilized clay generally has high shear strength, low compressibility, and relatively low permeability. Blended or mixed soils (sand and clay) should not be used as select fill.

All material intended for use as select fill should be tested prior to use to confirm that it meets select fill criteria. The fill should be placed in loose lifts not exceeding 8 inches in thickness. Backfill within 3 feet of walls or columns should be placed in loose lifts no more than 4-inches thick and compacted using hand tampers, or small self-propelled compactors. The lime-stabilized onsite soils or select fill should be compacted to a minimum of 95 percent of the ASTM D 698 (Standard Proctor) maximum dry unit weight at a moisture content ranging between optimum and 3 percent above optimum.

If imported select fill will be used, at least one Atterberg Limits and one percent passing a No. 200 sieve test shall be performed for each 5,000 square feet (sf) of placed fill, per lift (with a minimum of one set of tests per lift), to determine whether it meets select fill requirements. Prior to placement of concrete, the moisture contents of the top 2 lifts of compacted select fill shall be re-tested (if there is an extended period of time between fill placement and concrete placement) to determine if the in-place moisture content of the lifts have been maintained at the required moisture requirements.

6.0 CONSTRUCTION CONSIDERATIONS

6.1 Site Preparation and Grading

To mitigate site problems that may develop following prolonged periods of rainfall, it is essential to have adequate drainage to maintain a relatively dry and firm surface prior to starting any work at the site. Adequate drainage should be maintained throughout the construction period. Methods for controlling surface runoff and ponding include proper site grading, berm construction around exposed areas, and installation of sump pits with pumps.

6.2 Construction Monitoring

Site preparation (including clearing and proof-rolling), earthwork operations, foundation construction, and subgrade preparation should be monitored by qualified geotechnical professionals to check for compliance with project documents and changed conditions, if encountered.



7.0 GENERAL

AEC should be allowed to review construction documents and specifications prior to release to check that the geotechnical recommendations and design criteria presented herein are properly interpreted.

The information contained in this report summarizes conditions found on the dates the borings were drilled. The attached boring logs are true representations of the soils encountered at the specific boring locations on the date of drilling. Due to variations encountered in the subsurface conditions across the site, changes in soil conditions from those presented in this report should be anticipated. AEC should be notified immediately when conditions encountered during construction are significantly different from those presented in this report.

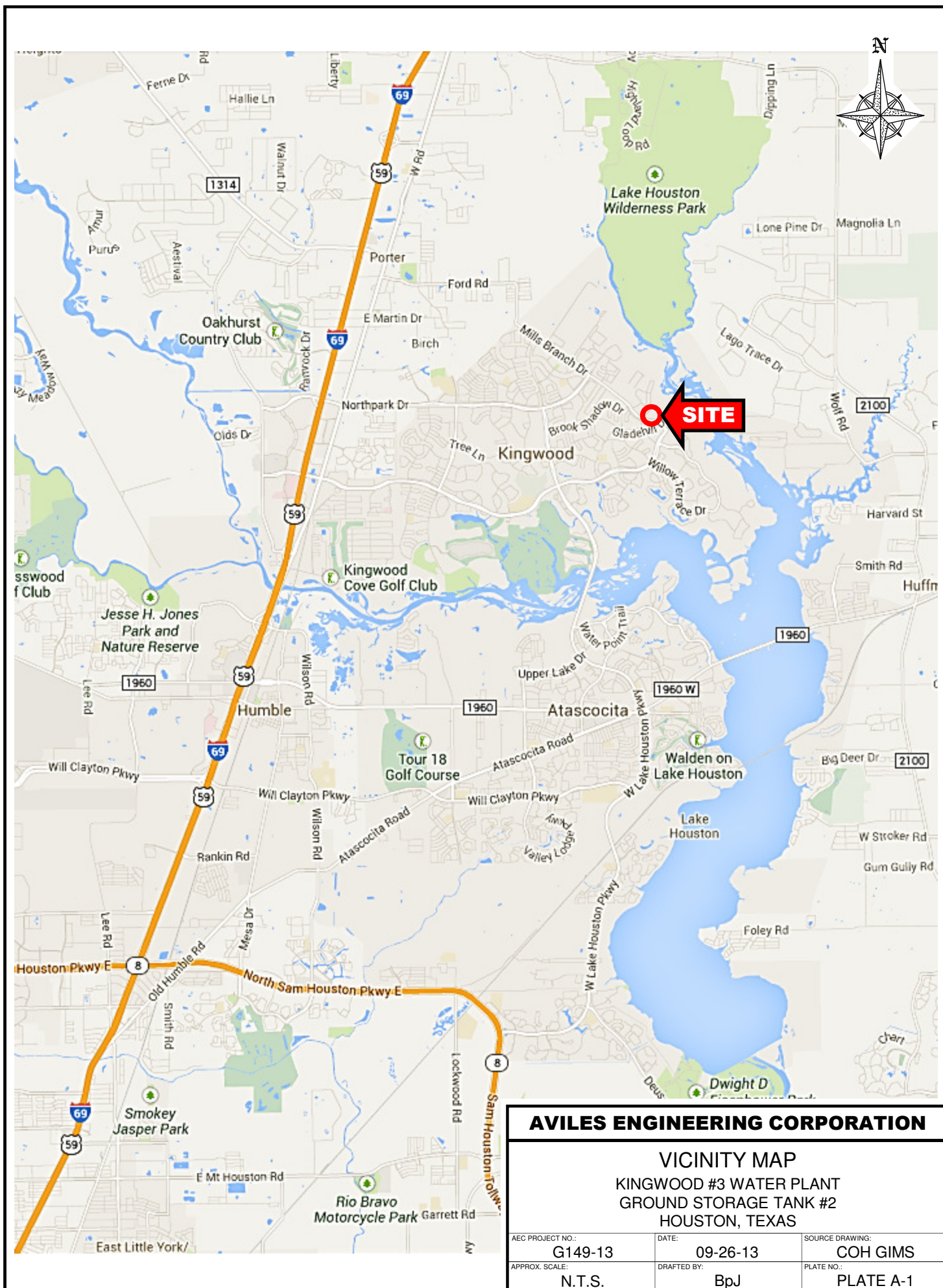
8.0 LIMITATIONS

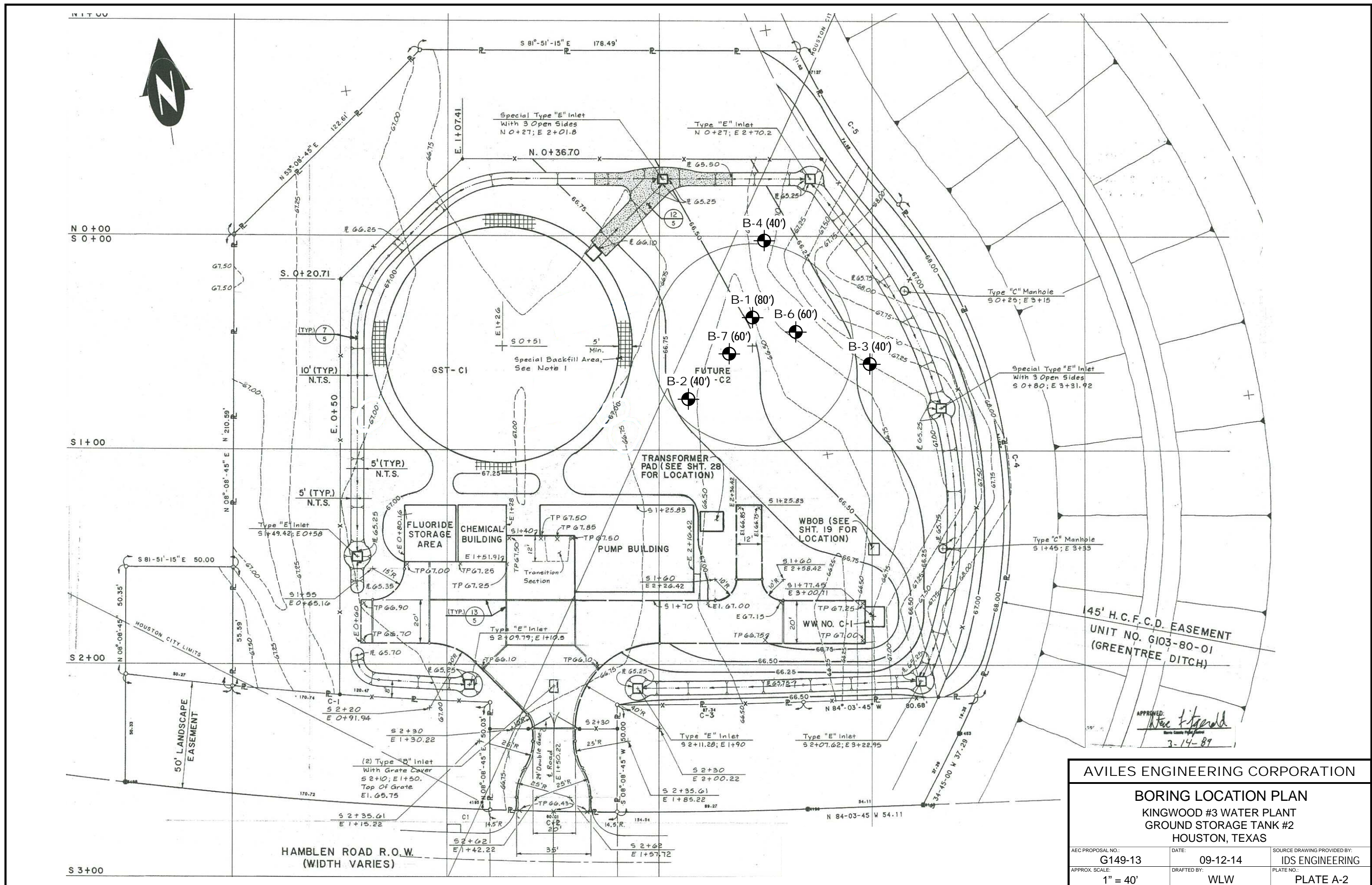
The investigation was performed using the standard level of care and diligence normally practiced by recognized geotechnical engineering firms in this area, presently performing similar services under similar circumstances. The report has been prepared exclusively for the project and location described in this report, and is intended to be used in its entirety. If pertinent project details change or otherwise differ from those described herein, AEC should be notified immediately and retained to evaluate the effect of the changes on the recommendations presented in this report, and revise the recommendations if necessary. The scope of services does not include a fault investigation. The recommendations presented in this report should not be used for other structures located at this site or similar structures located at other sites, without additional evaluation and/or investigation.



APPENDIX A

Plate A-1	Vicinity Map
Plate A-2	Boring Location Plan
Plates A-3 to A-9	Boring Logs
Plate A-10	Key to Symbols
Plate A-11	Classification of Soils for Engineering Purposes
Plate A-12	Terms Used on Boring Logs
Plate A-13	ASTM & TXDOT Designation for Soil Laboratory Tests
Plate A-14	Sieve Analysis Results
Plates A-15 to A-18	Consolidation Results
Plates A-19 to A-20	Estimated Time Rate of Consolidation Settlement





AVILES ENGINEERING CORPORATION		
BORING LOCATION PLAN		
KINGWOOD #3 WATER PLANT GROUND STORAGE TANK #2 HOUSTON, TEXAS		
AEC PROPOSAL NO: G149-13	DATE: 09-12-14	SOURCE DRAWING PROVIDED BY: IDS ENGINEERING
APPROX. SCALE: 1" = 40'	DRAFTED BY: WLW	PLATE NO.: PLATE A-2



B-1

LOCATION See Boring Location Plan



BORING DRILLED TO 28 FEET WITHOUT DRILLING FLUID
WATER ENCOUNTERED AT 24 FEET WHILE DRILLING 
WATER LEVEL AT 16 FEET AFTER 24 HRS 
DRILLED BY V&S DRAFTED BY CHL

PLATE A-3



ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

BORING

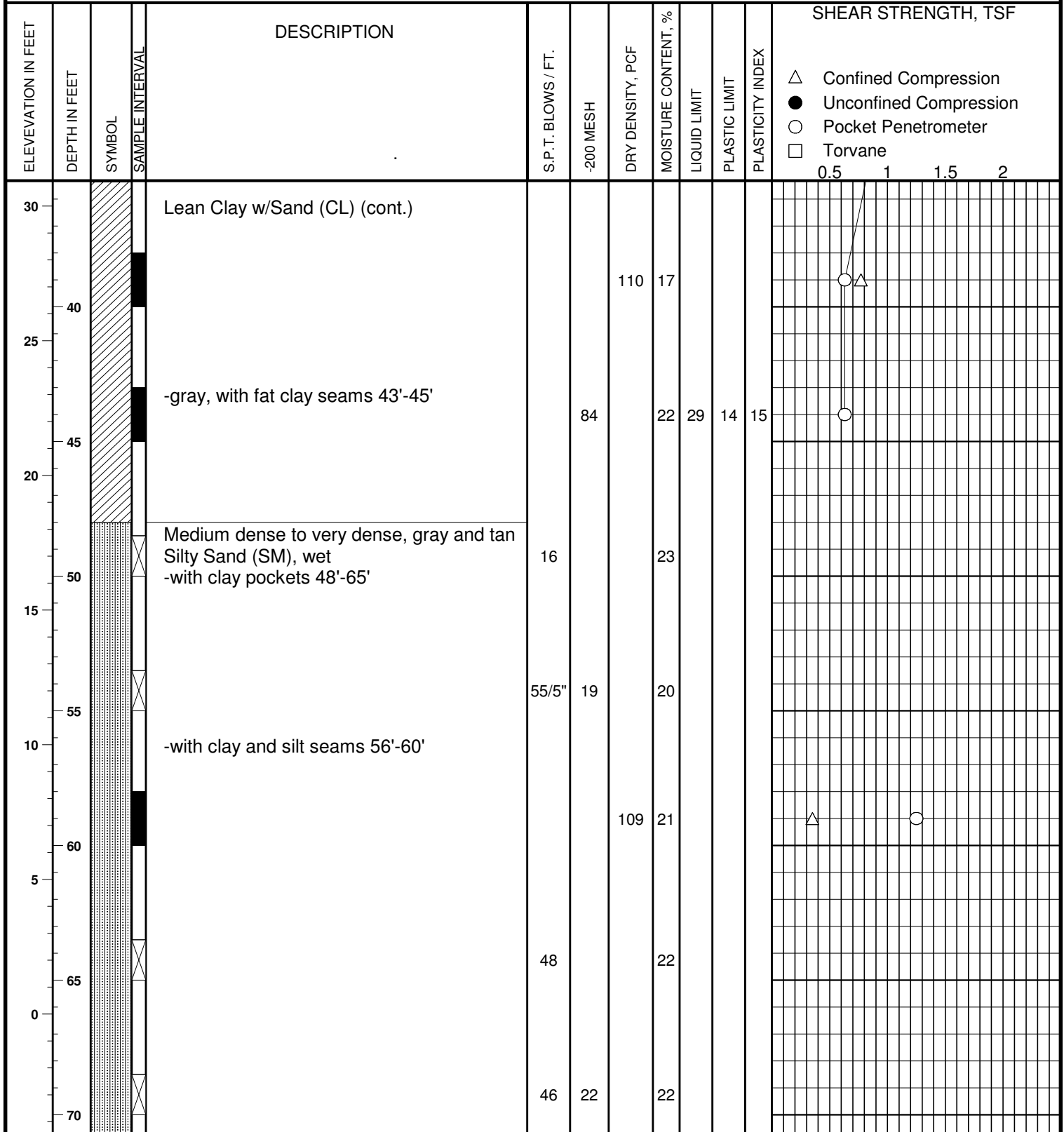
B-1

PROJECT: **Kingwood #3 Water Plant, GST #2**

DATE **8/23/13**

TYPE **4" Dry Auger/Wet Rotary**

LOCATION **See Boring Location Plan**



BORING DRILLED TO 28 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 24 FEET WHILE DRILLING

WATER LEVEL AT 16 FEET AFTER 24 HRS

DRILLED BY V&S DRAFTED BY CHL LOGGED BY AEC



ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

BORING

B-1

PROJECT: Kingwood #3 Water Plant, GST #2

DATE 8/23/13

TYPE 4" Dry Auger/Wet Rotary

LOCATION See Boring Location Plan

ELEVATION IN FEET	DEPTH IN FEET	SYMBOL	SAMPLE INTERVAL	DESCRIPTION	S.P.T. BLOWS / FT.	-200 MESH	DRY DENSITY, PCF	MOISTURE CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	SHEAR STRENGTH, TSF			
												Confined Compression	Unconfined Compression	Pocket Penetrometer	Torvane
												0.5	1	1.5	2
-5				Silty Sand (SM) (cont.)											
	75				54/4"			21							
-10															
	80			-light gray 78'-80'	88			18							
-15				Termination depth = 80 feet.											
	85														
-20															
	90														
-25															
	95														
-30															
	100														
-35															
	105														

BORING DRILLED TO 28 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 24 FEET WHILE DRILLING

WATER LEVEL AT 16 FEET AFTER 24 HRS

DRILLED BY V&S DRAFTED BY CHL LOGGED BY AEC



ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

BORING

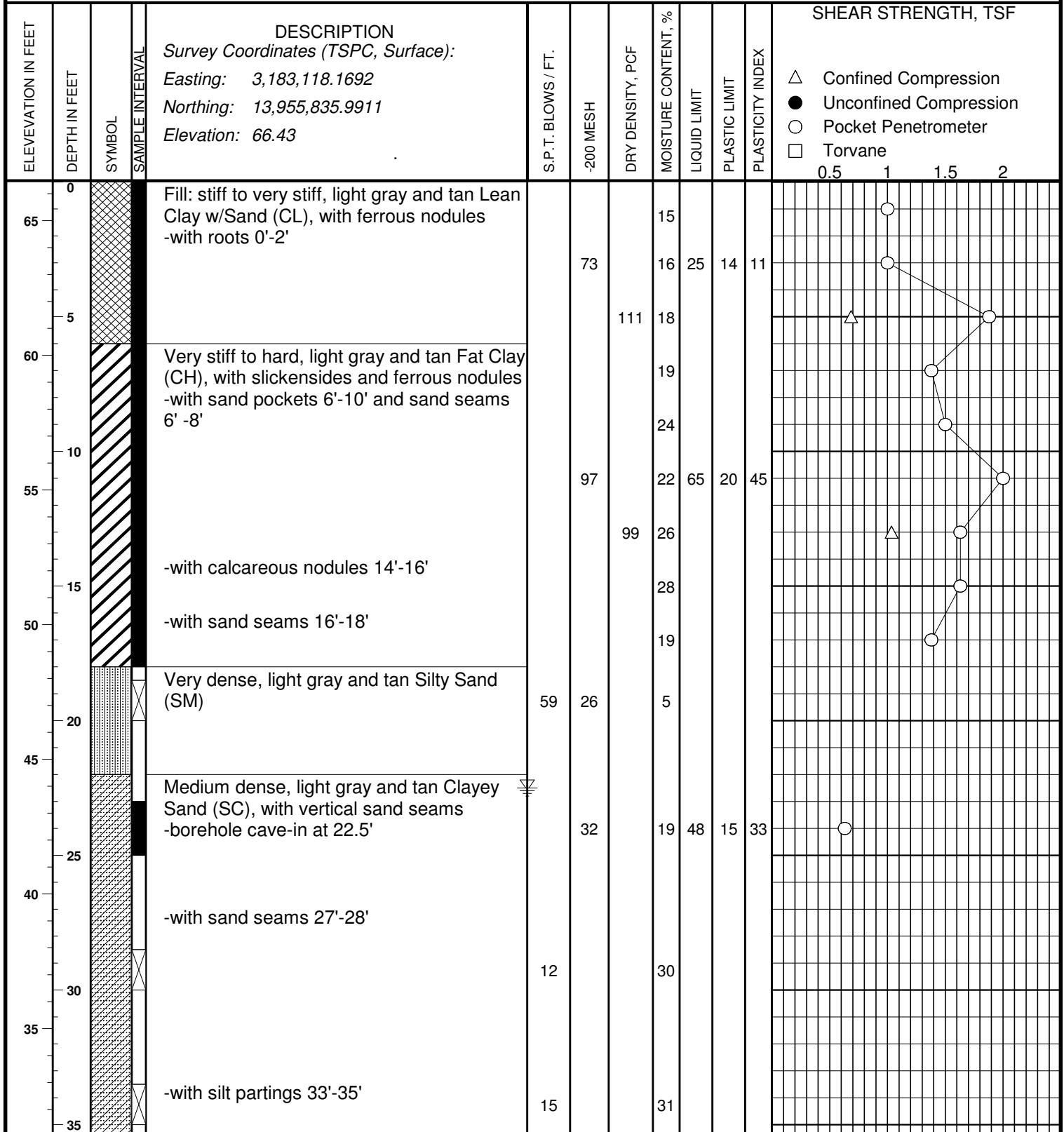
B-2

PROJECT: **Kingwood #3 Water Plant, GST #2**

DATE **8/27/13**

TYPE **4" Dry Auger/Wet Rotary**

LOCATION **See Boring Location Plan**



BORING DRILLED TO 25 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 22.5 FEET WHILE DRILLING

WATER LEVEL AT N/A FEET AFTER **COMPLETE**

DRILLED BY V&S DRAFTED BY CHL LOGGED BY AEC



ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

BORING

B-2

PROJECT: Kingwood #3 Water Plant, GST #2

DATE 8/27/13

TYPE 4" Dry Auger/Wet Rotary

LOCATION See Boring Location Plan

ELEVATION IN FEET	DEPTH IN FEET	SYMBOL	SAMPLE INTERVAL	DESCRIPTION	S.P.T. BLOWS / FT.	-200 MESH	DRY DENSITY, PCF	MOISTURE CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	SHEAR STRENGTH, TSF			
30				Clayey Sand (SC) (cont.)											
				Stiff to very stiff, tan and light gray Lean Clay (CL), with fat clay pockets		89	109	19	44	16	28				
40				Termination depth = 40 feet.											
25															
45															
20															
50															
15															
55															
10															
60															
5															
65															
0															
70															

BORING DRILLED TO 25 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 22.5 FEET WHILE DRILLING

WATER LEVEL AT N/A FEET AFTER COMPLETE

DRILLED BY V&S DRAFTED BY CHL LOGGED BY AEC



ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

BORING

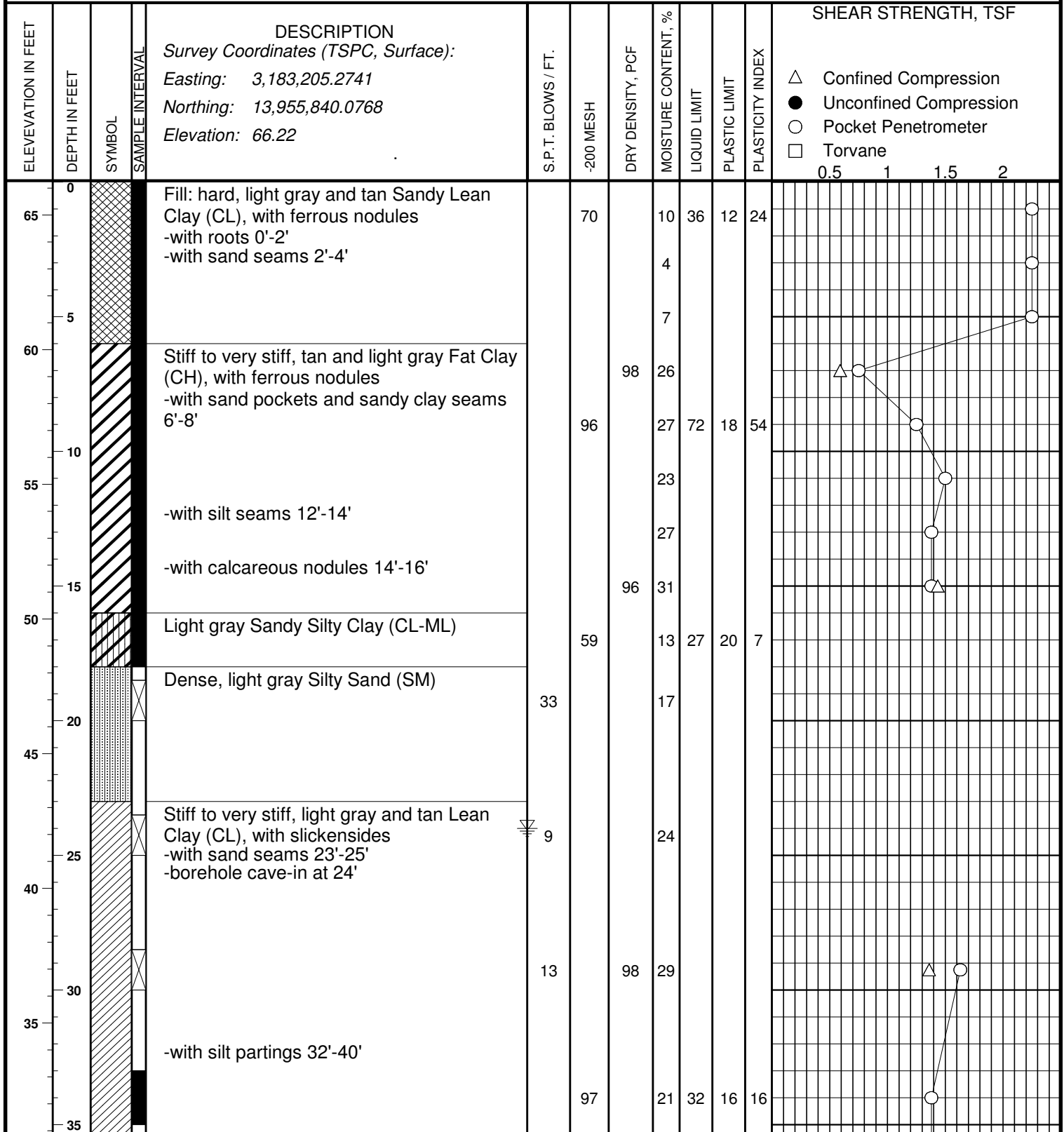
B-3

PROJECT: **Kingwood #3 Water Plant, GST #2**

DATE **8/23/13**

TYPE **4" Dry Auger/Wet Rotary**

LOCATION **See Boring Location Plan**



BORING DRILLED TO 24 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 24 FEET WHILE DRILLING

WATER LEVEL AT N/A FEET AFTER **COMPLETE**

DRILLED BY V&S DRAFTED BY CHL LOGGED BY AEC



ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

BORING

B-3

PROJECT: Kingwood #3 Water Plant, GST #2

DATE 8/23/13

TYPE 4" Dry Auger/Wet Rotary

LOCATION See Boring Location Plan

ELEVATION IN FEET	DEPTH IN FEET	SYMBOL	SAMPLE INTERVAL	DESCRIPTION	S.P.T. BLOWS / FT.	-200 MESH	DRY DENSITY, PCF	MOISTURE CONTENT, %	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	SHEAR STRENGTH, TSF
												<div>△ Confined Compression</div> <div>● Unconfined Compression</div> <div>○ Pocket Penetrometer</div> <div>□ Torvane</div> <div>0.511.52</div>
30				Lean Clay (CL) (cont.)								
				-with fat clay pockets 38'-40'				19				
40				Termination depth = 40 feet.								
25												
45												
20												
50												
15												
55												
10												
60												
5												
65												
0												
70												

BORING DRILLED TO 24 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 24 FEET WHILE DRILLING

WATER LEVEL AT N/A FEET AFTER COMPLETE

DRILLED BY V&S DRAFTED BY CHL LOGGED BY AEC



ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

BORING

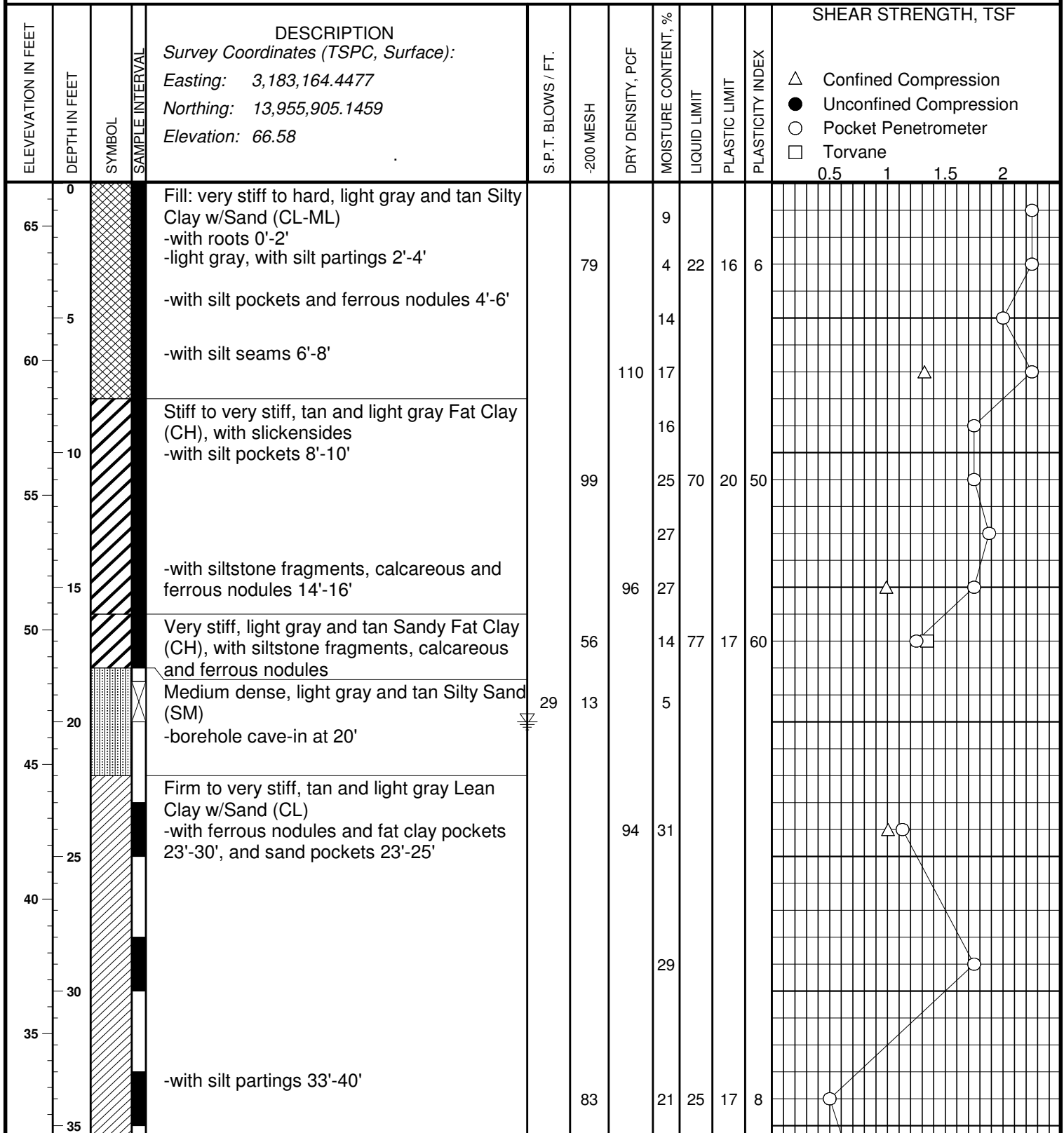
B-4

PROJECT: **Kingwood #3 Water Plant, GST #2**

DATE **8/27/13**

TYPE **4" Dry Auger/Wet Rotary**

LOCATION **See Boring Location Plan**



BORING DRILLED TO 25 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 20 FEET WHILE DRILLING

WATER LEVEL AT N/A FEET AFTER **COMPLETE**

DRILLED BY V&S DRAFTED BY CHL LOGGED BY AEC



ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

BORING

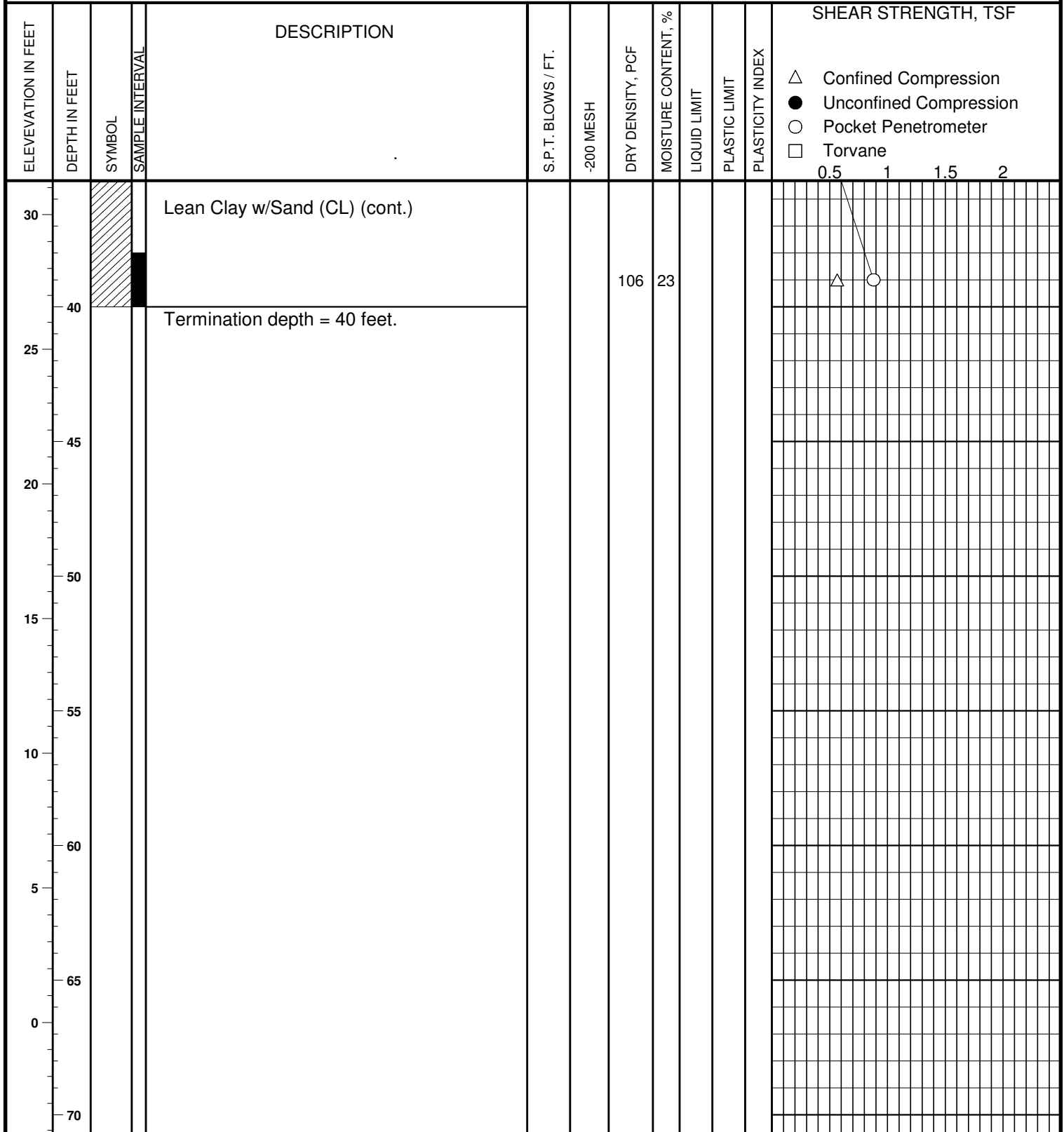
B-4

PROJECT: Kingwood #3 Water Plant, GST #2

DATE 8/27/13

TYPE 4" Dry Auger/Wet Rotary

LOCATION See Boring Location Plan



BORING DRILLED TO 25 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 20 FEET WHILE DRILLING

WATER LEVEL AT N/A FEET AFTER COMPLETE

DRILLED BY V&S DRAFTED BY CHL LOGGED BY AEC

PROJECT: **Kingwood #3 Water Plant, GST #2**

BORING

B-5

DATE

TYPE

LOCATION

[illegible]

BORING DRILLED TO FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT _____ FEET WHILE DRILLING 

WATER LEVEL AT _____ FEET AFTER _____ 

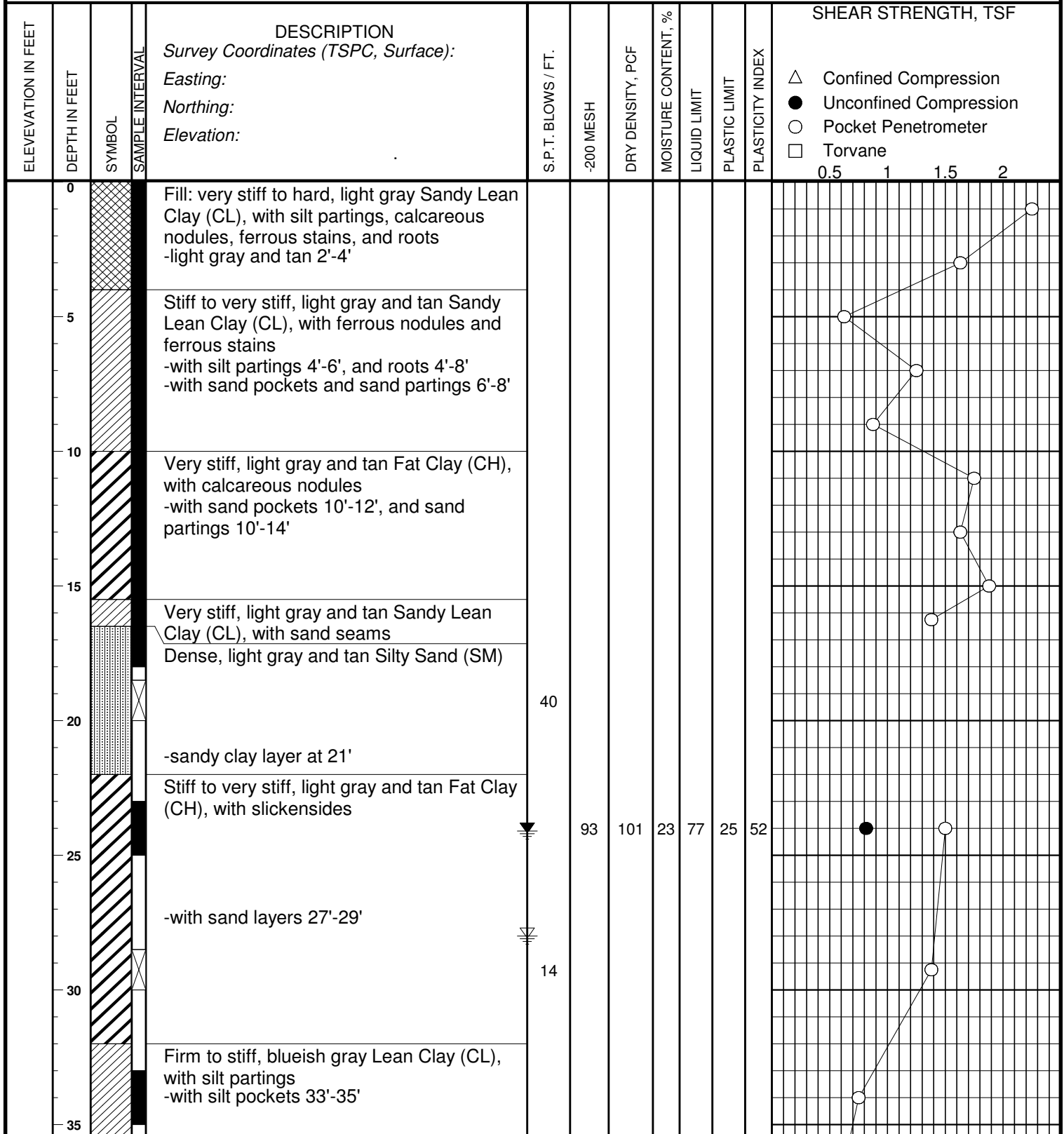
DRILLED BY _____ DRAFTED BY _____ LOGGED BY _____

PROJECT: **Kingwood #3 Water Plant, GST #2**

DATE **8/27/14**

TYPE **4" Dry Auger / Wet Rotary**

LOCATION **See Boring Location Plan**



BORING DRILLED TO 28 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 28 FEET WHILE DRILLING

WATER LEVEL AT 24.1 FEET AFTER 1/4 HR

DRILLED BY V&S

DRAFTED BY BPJ

LOGGED BY RJM



ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

BORING

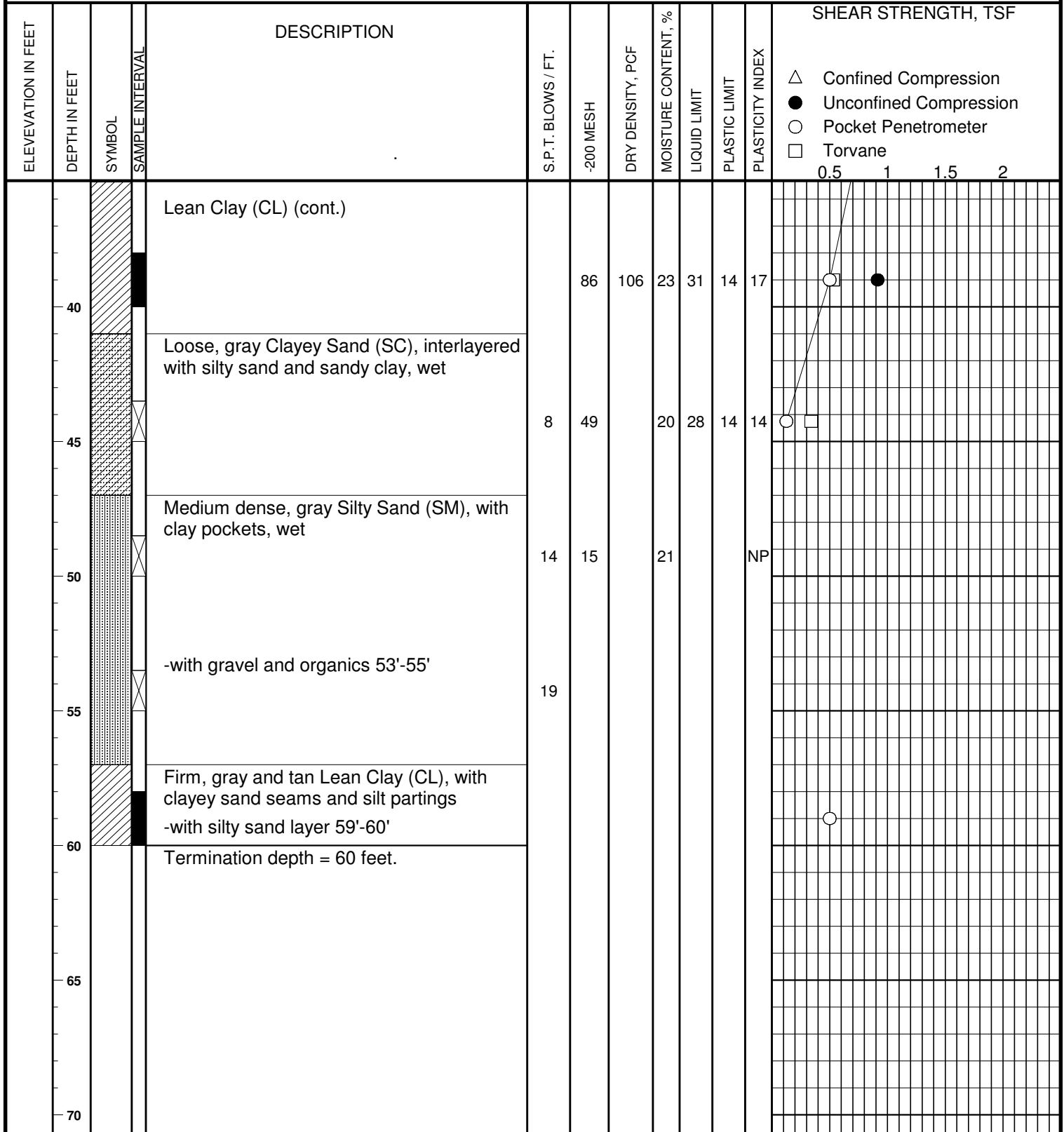
B-6

PROJECT: **Kingwood #3 Water Plant, GST #2**

DATE **8/27/14**

TYPE **4" Dry Auger / Wet Rotary**

LOCATION **See Boring Location Plan**



BORING DRILLED TO 28 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 28 FEET WHILE DRILLING

WATER LEVEL AT 24.1 FEET AFTER 1/4 HR

DRILLED BY V&S DRAFTED BY BPJ LOGGED BY RJM



ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

BORING

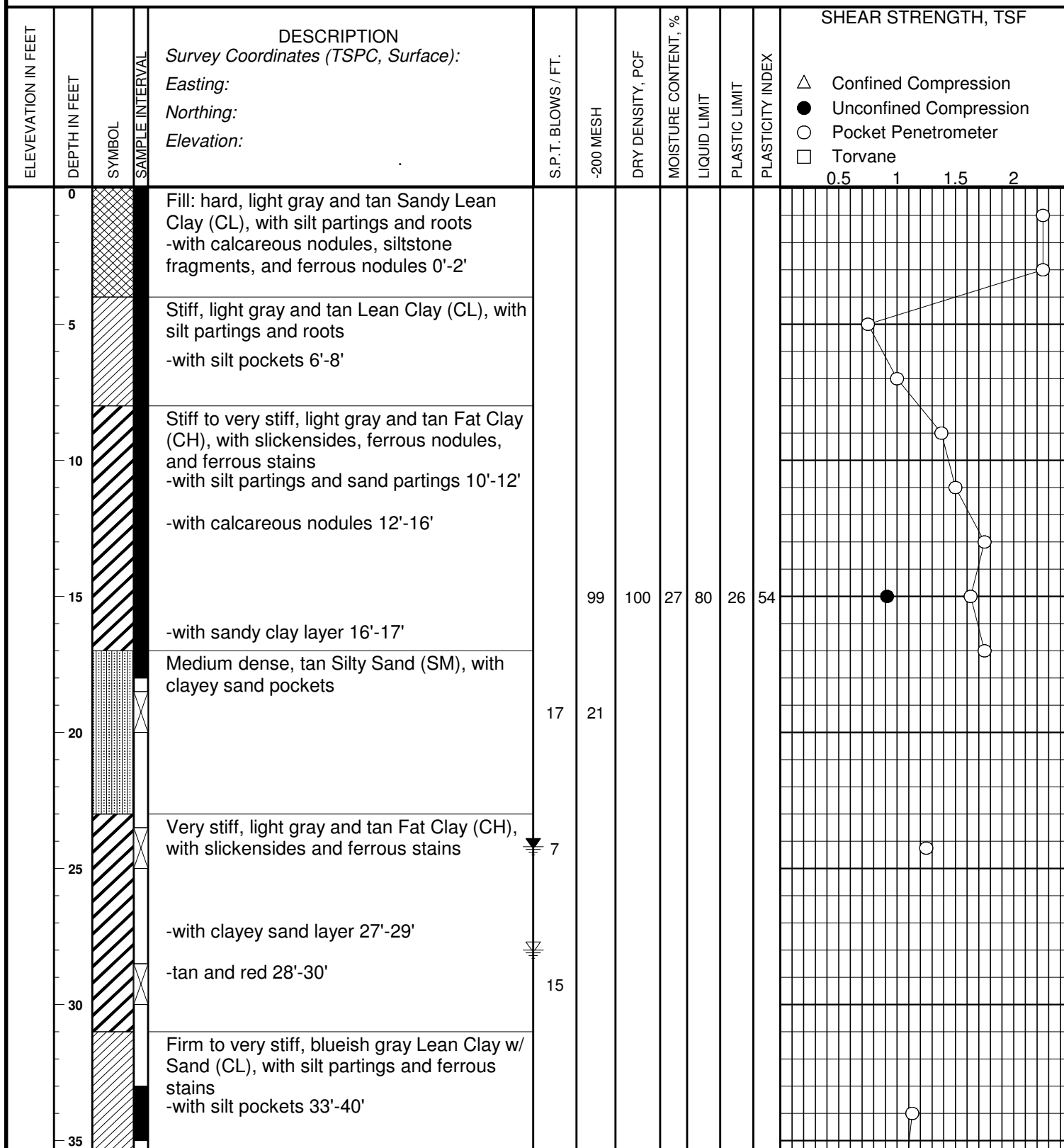
B-7

PROJECT: **Kingwood #3 Water Plant, GST #2**

DATE **8/27/14**

TYPE **4" Dry Auger / Wet Rotary**

LOCATION **See Boring Location Plan**



BORING DRILLED TO **28** FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT **28** FEET WHILE DRILLING

WATER LEVEL AT **24.2** FEET AFTER **1/4 HR**

DRILLED BY **V&S** DRAFTED BY **BPJ** LOGGED BY **RJM**



ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

BORING

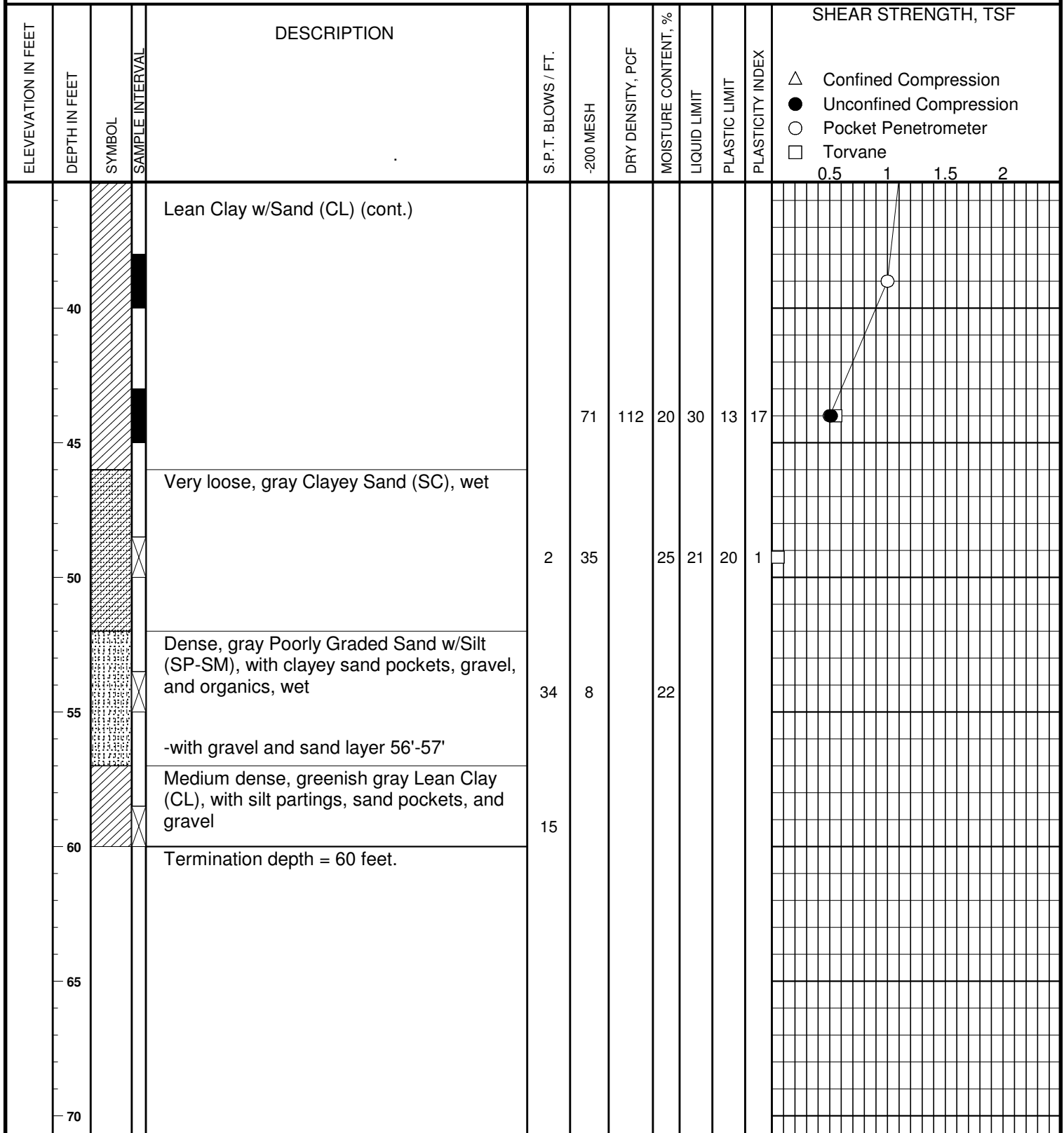
B-7

PROJECT: **Kingwood #3 Water Plant, GST #2**

DATE **8/27/14**

TYPE **4" Dry Auger / Wet Rotary**

LOCATION **See Boring Location Plan**



BORING DRILLED TO 28 FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT 28 FEET WHILE DRILLING

WATER LEVEL AT 24.2 FEET AFTER 1/4 HR

DRILLED BY V&S DRAFTED BY BPJ LOGGED BY RJM

KEY TO SYMBOLS

Symbol Description

Strata symbols



Fill



Low plasticity
clay



Poorly graded clayey
silty sand



Clayey sand



Silty sand



High plasticity
clay



Silty low plasticity
clay



Poorly graded sand
with silt

Misc. Symbols



Water table depth
during drilling



Subsequent water
table depth



Pocket Penetrometer



Confined Compression



Torvane



Unconfined Compression

Symbol Description

Soil Samplers



Undisturbed thin wall
Shelby tube



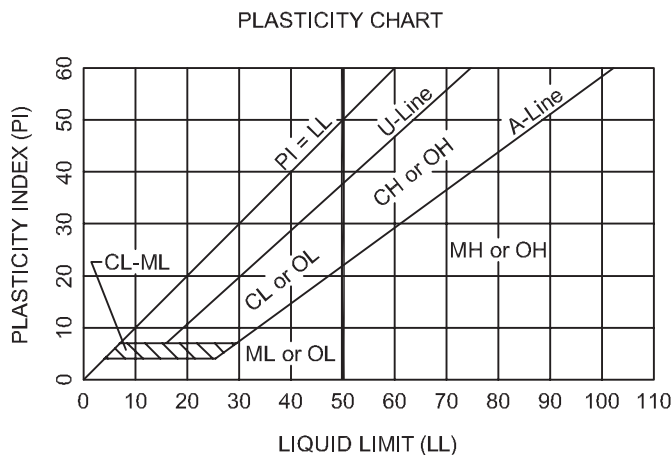
Standard penetration test

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation D-2487

MAJOR DIVISIONS				GROUP SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (Less than 50% of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)		GW	Well-graded gravel, well-graded gravel with sand
				GP	Poorly-graded gravel, poorly-graded gravel with sand
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart	GM	Silty gravel, silty gravel with sand
			Limits plot above "A" line & hatched zone on plasticity chart	GC	Clayey gravel, clayey gravel with sand
	SANDS (50% or more of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 sieve)		SW	Well-graded sand, well-graded sand with gravel
				SP	Poorly-graded sand, poorly-graded sand with gravel
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart	SM	Silty sand, silty sand with gravel
			Limits plot above "A" line & hatched zone on plasticity chart	SC	Clayey sand, clayey sand with gravel
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS AND CLAYS (Liquid Limit Less Than 50%)		ML	Silt, silt with sand, silt with gravel, sandy silt, gravelly silt	
			CL	Lean clay, lean clay with sand, lean clay with gravel, sandy lean clay, gravelly lean clay	
			OL	Organic clay, organic clay with sand, sandy organic clay, organic silt, sandy organic silt	
	SILTS AND CLAYS (Liquid Limit 50% or More)		MH	Elastic silt, elastic silt with sand, sandy elastic silt, gravelly elastic silt	
			CH	Fat clay, fat clay with sand, fat clay with gravel, sandy fat clay, gravelly fat clay	
			OH	Organic clay, organic clay with sand, sandy organic clay, organic silt, sandy organic silt	

NOTE: Coarse soils between 5% and 12% passing the No. 200 sieve and fine-grained soils with limits plotting in the hatched zone of the plasticity chart are to have dual symbols.



DEGREE OF PLASTICITY OF COHESIVE SOILS

Degree of Plasticity Plasticity Index

None 0 - 4
Slight 5 - 10
Medium 11 - 20
High 21 - 40
Very High..... >40

SOIL SYMBOLS



Fill



Clay (CH)



Clay (CL)



Sand



Silt

TERMS USED ON BORING LOGS

SOIL GRAIN SIZE

U.S. STANDARD SIEVE

6"	3"	3/4"	#4	#10	#40	#200		
BOULDERS	COBBLES	GRAVEL		SAND			SILT	CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE		
152	76.2	19.1	4.76	2.00	0.420	0.074	0.002	

SOIL GRAIN SIZE IN MILLIMETERS

STRENGTH OF COHESIVE SOILS

<u>Consistency</u>	Undrained Shear Strength, Kips per Sq. ft.
Very Soft	less than 0.25
Soft	0.25 to 0.50
Firm	0.50 to 1.00
Stiff	1.00 to 2.00
Very Stiff	2.00 to 4.00
Hard	greater than 4.00

RELATIVE DENSITY OF COHESIONLESS SOILS FROM STANDARD PENETRATION TEST

Very Loose	<4 bpf
Loose	5-10 bpf
Medium Dense	11-30 bpf
Dense	31-50 bpf
Very Dense	>50 bpf

SPLIT-BARREL SAMPLER DRIVING RECORD

Blows per Foot

Description

25	25 blows driving sampler 12 inches, after initial 6 inches of seating.
50/7"	50 blows driving sampler 7 inches, after initial 6 inches of seating.
Ref/3"	50 blows driving sampler 3 inches, during initial 6-inches seating interval.

NOTE: To avoid change to sampling tools, driving is limited to 50 blows during or after seating interval.

DRY STRENGTH ASTM D2488

None	Dry specimen crumbles into powder with mere pressure of handling
Low	Dry specimen crumbles into powder with some finger pressure
Medium	Dry specimen breaks into pieces or crumbles with considerable pressure
High	Dry specimen cannot be broken with finger pressure, it can be broken between thumb and hard surface
Very High	Dry specimen cannot be broken between thumb and hard surface

MOISTURE CONDITION ASTM D2488

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water

SOIL STRUCTURE

Slickensided	Having planes of weakness that appear slick and glossy. The degree of slickensidedness depends upon the spacing of slickensides and the easiness of breaking along these planes.
Fissured	Containing shrinkage or relief cracks, often filled with fine sand or silt; usually more or less vertical.
Pocket	Inclusion of material of different texture that is smaller than the diameter of the sample.
Parting	Inclusion less than 1/8 inch thick extending through the sample.
Seam	Inclusion 1/8 inch to 3 inches thick extending through the sample.
Layer	Inclusion greater than 3 inches thick extending through the sample.
Laminated	Soil sample composed of alternating partings or seams of different soil types.
Interlayered	Soil sample composed of alternating layers of different soil types.
Intermixed	Soil sample composed of pockets of different soil types and layered or laminated structure is not evident.
Calcareous	Having appreciable quantities of calcium material.

ASTM & TXDOT DESIGNATION FOR SOIL LABORATORY TESTS

NAME OF TEST	ASTM TEST DESIGNATION	TXDOT TEST DESIGNATION
Moisture Content	D 2216	Tex-103-E
Specific Gravity	D 854	Tex-108-E
Sieve Analysis	D 421 D 422	Tex-110-E (Part 1)
Hydrometer Analysis	D 422	Tex-110-E (Part 2)
Minus No. 200 Sieve	D 1140	Tex-111-E
Liquid Limit	D 4318	Tex-104-E
Plastic Limit	D 4318	Tex-105-E
Shrinkage Limit	D 427	Tex-107-E
Standard Proctor Compaction	D 698	Tex-114-E
Modified Proctor Compaction	D 1557	Tex-113-E
Permeability (constant head)	D 2434	-
Consolidation	D 2435	-
Direct Shear	D 3080	-
Unconfined Compression	D 2166	-
Unconsolidated-Undrained Triaxial	D 2850	Tex-118-E
Consolidated-Undrained Triaxial	D 4767	Tex-131-E
Pinhole Test	D 4647	-
California Bearing Ratio	D 1883	-
Unified Soil Classification System	D 2487	Tex-142-E

AVILES ENGINEERING CORPORATION

Consulting Engineers - Geotechnical, Construction Materials Testing, Environmental

GRAIN SIZE ANALYSIS - SIEVE & HYDROMETER

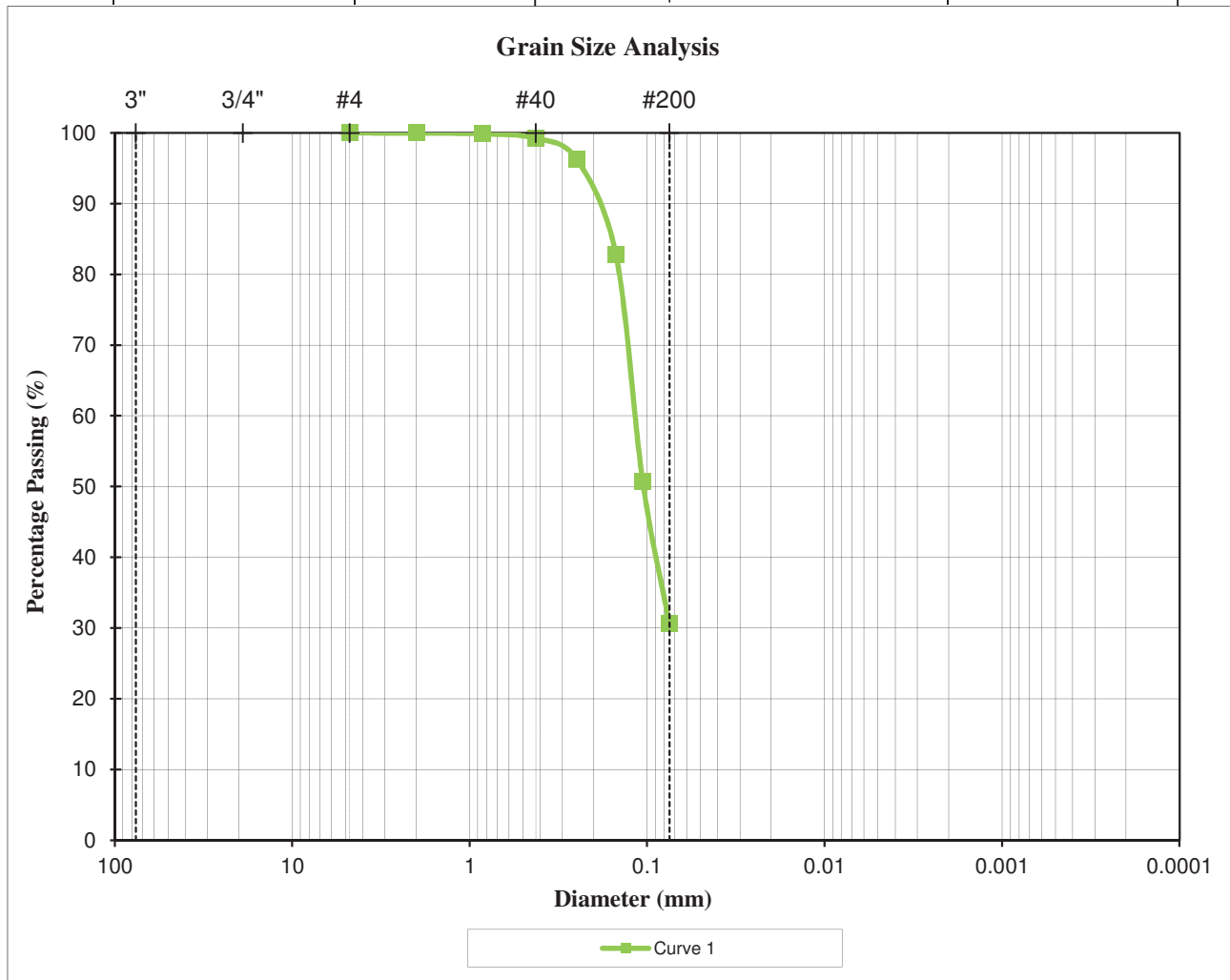
Project : Kingwood #3 Water Plant, GST #2

Job No.: G149-13

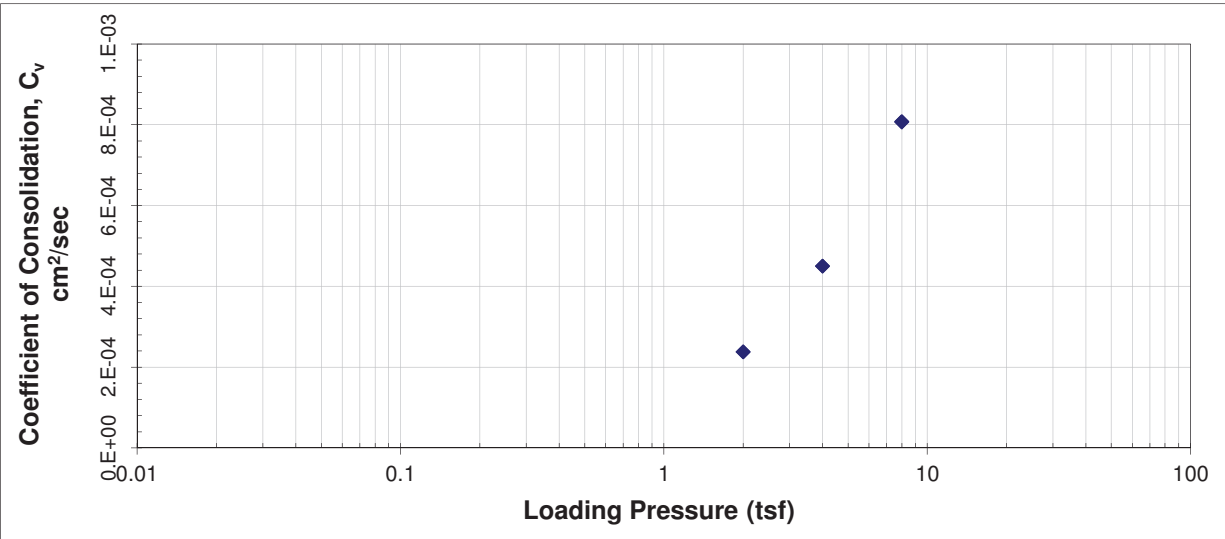
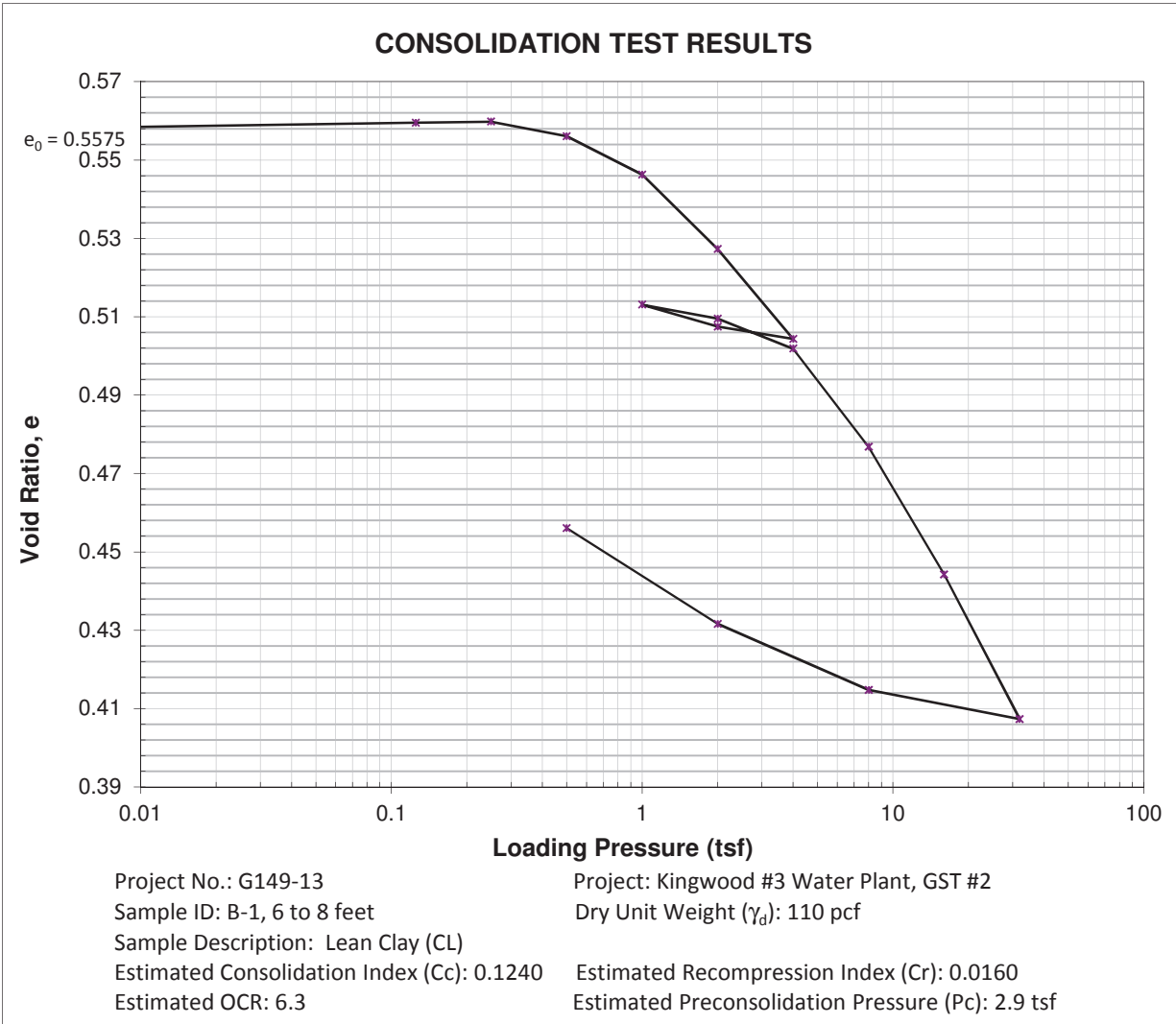
Location of Project: Houston, Texas

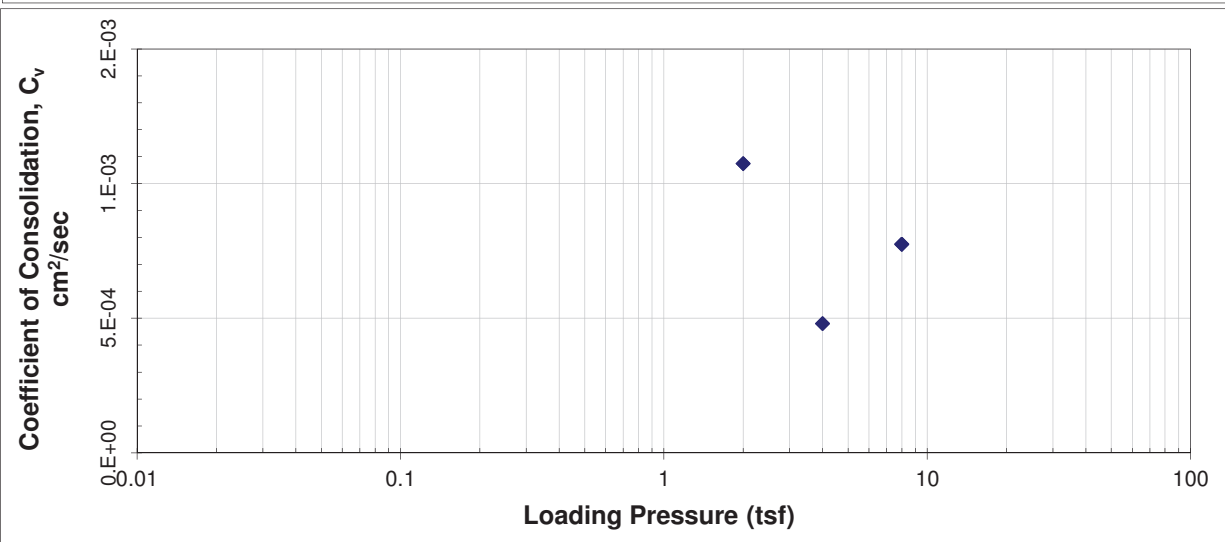
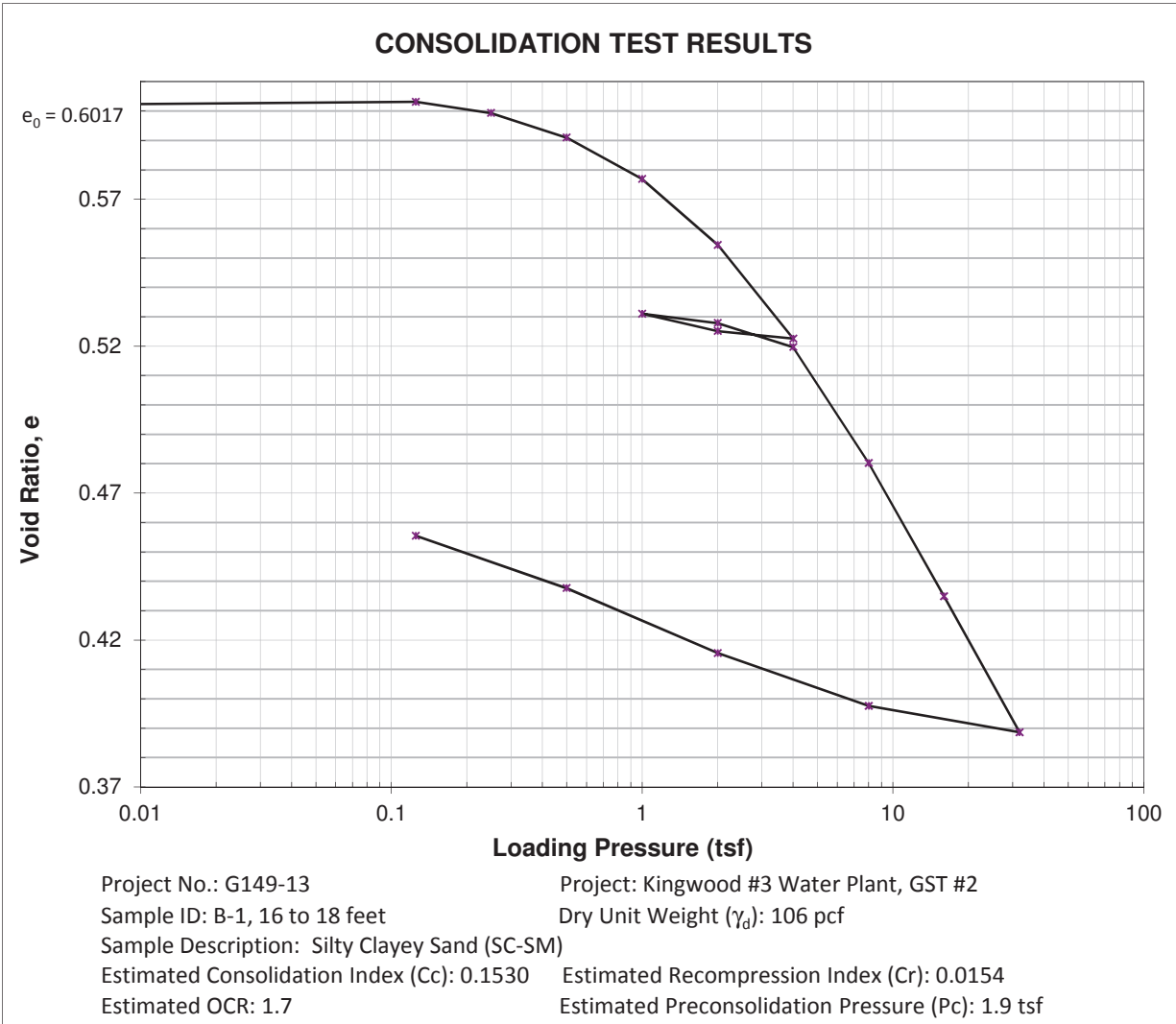
Date of Testing: 9/5/2013

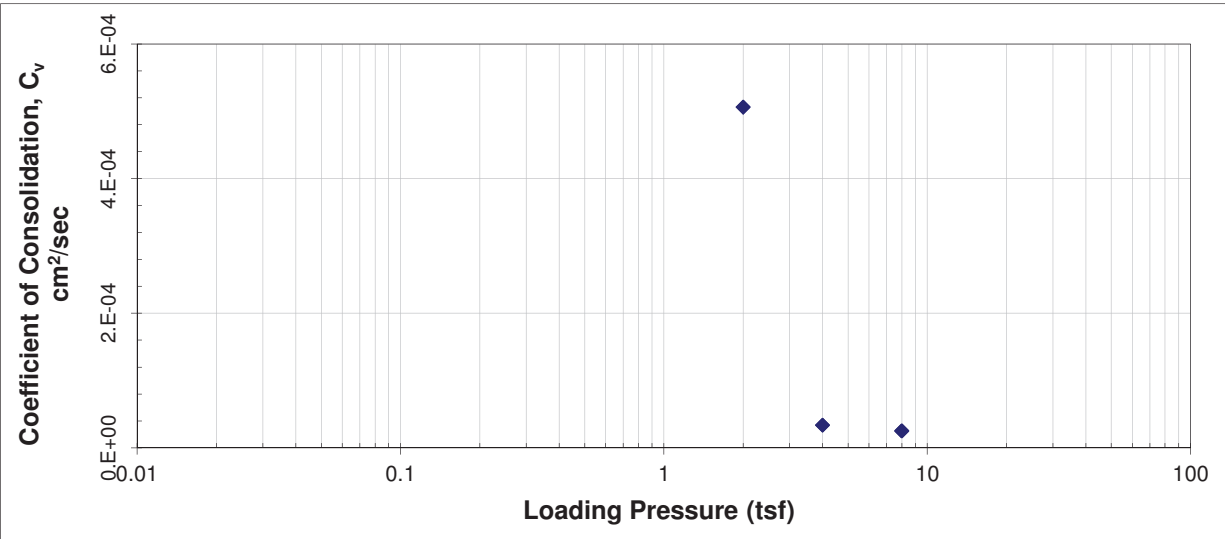
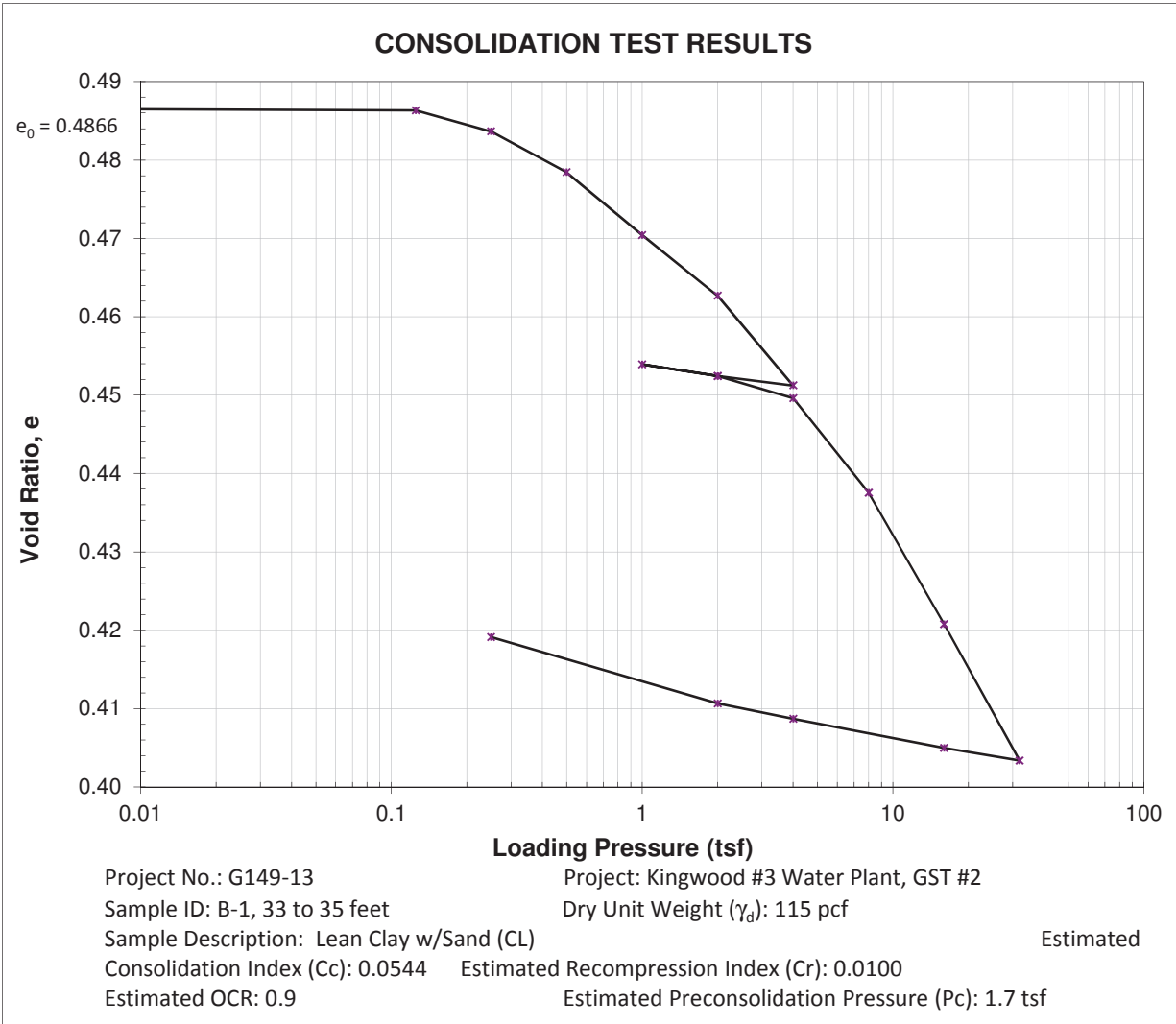
	Gravel	Sand		Silt	Clay
		Coarse to Medium	Fine		

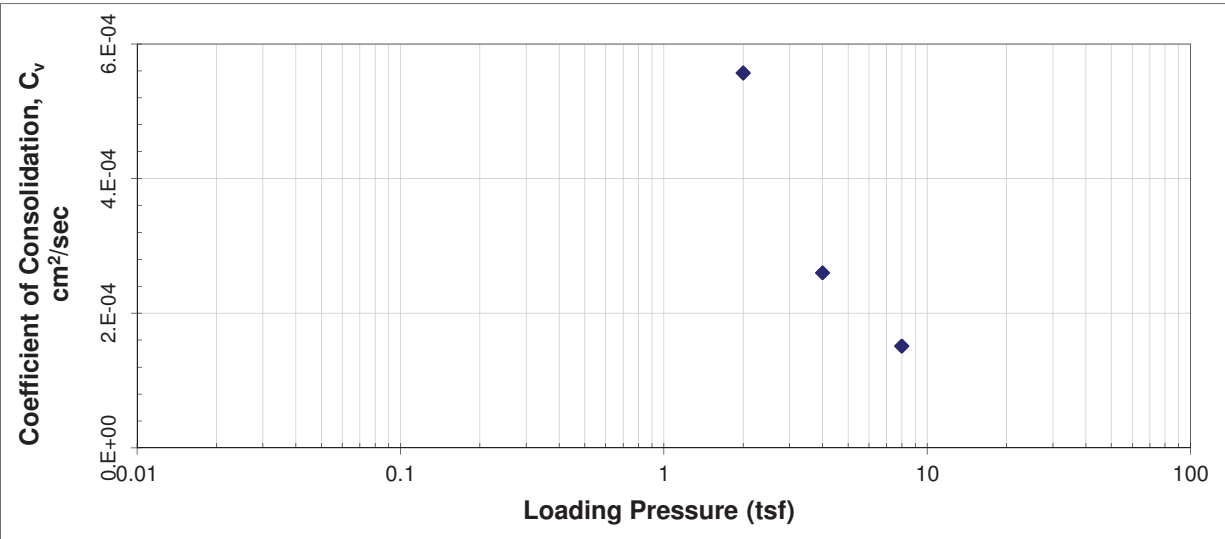
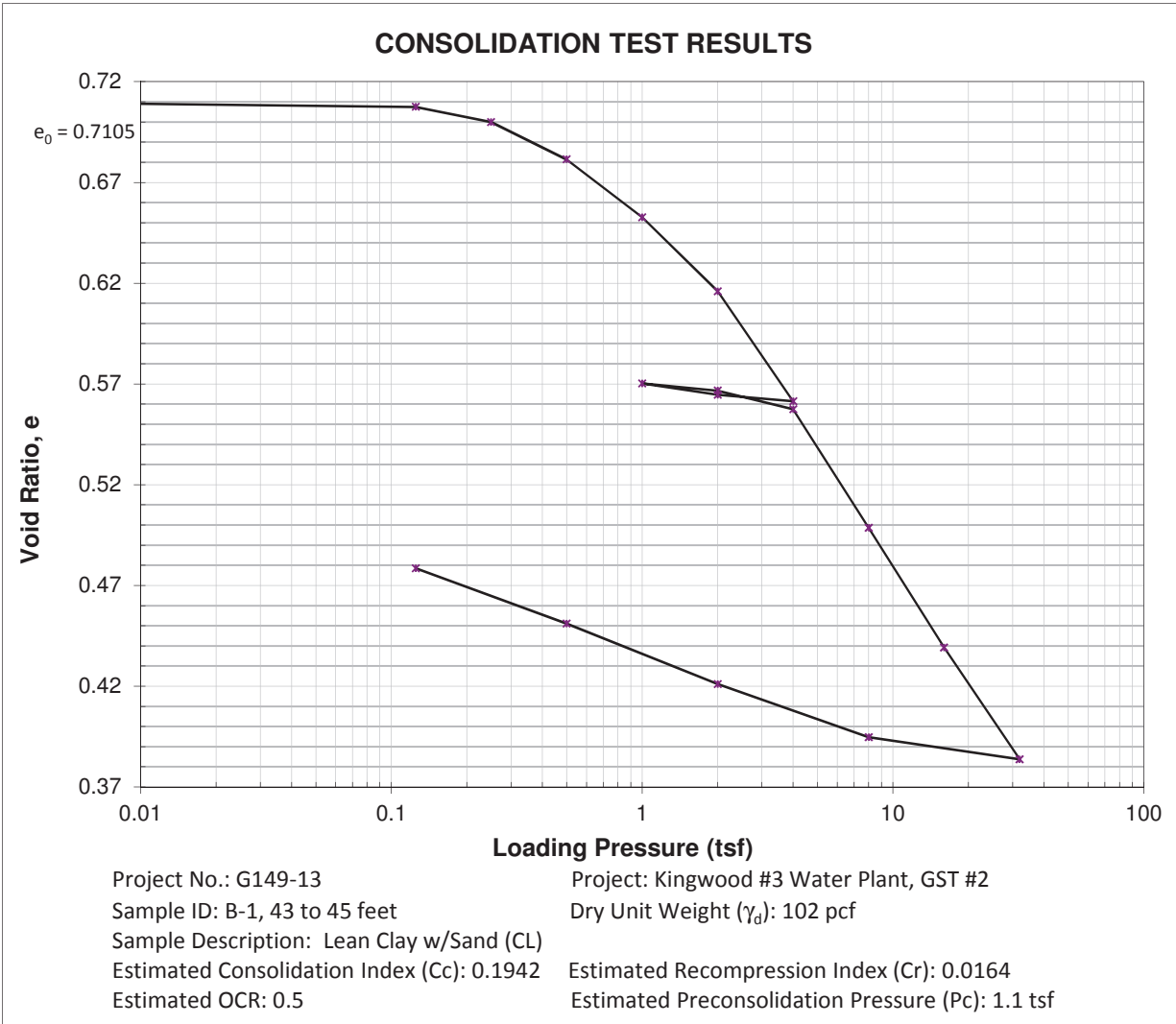


<u>Curve</u>	<u>Boring</u>	<u>Depth (ft)</u>	<u>Soil Description</u>	<u>Cu</u>	<u>Cc</u>
1	B-1	28-30	Clayey Sand (SC)	N/A	N/A

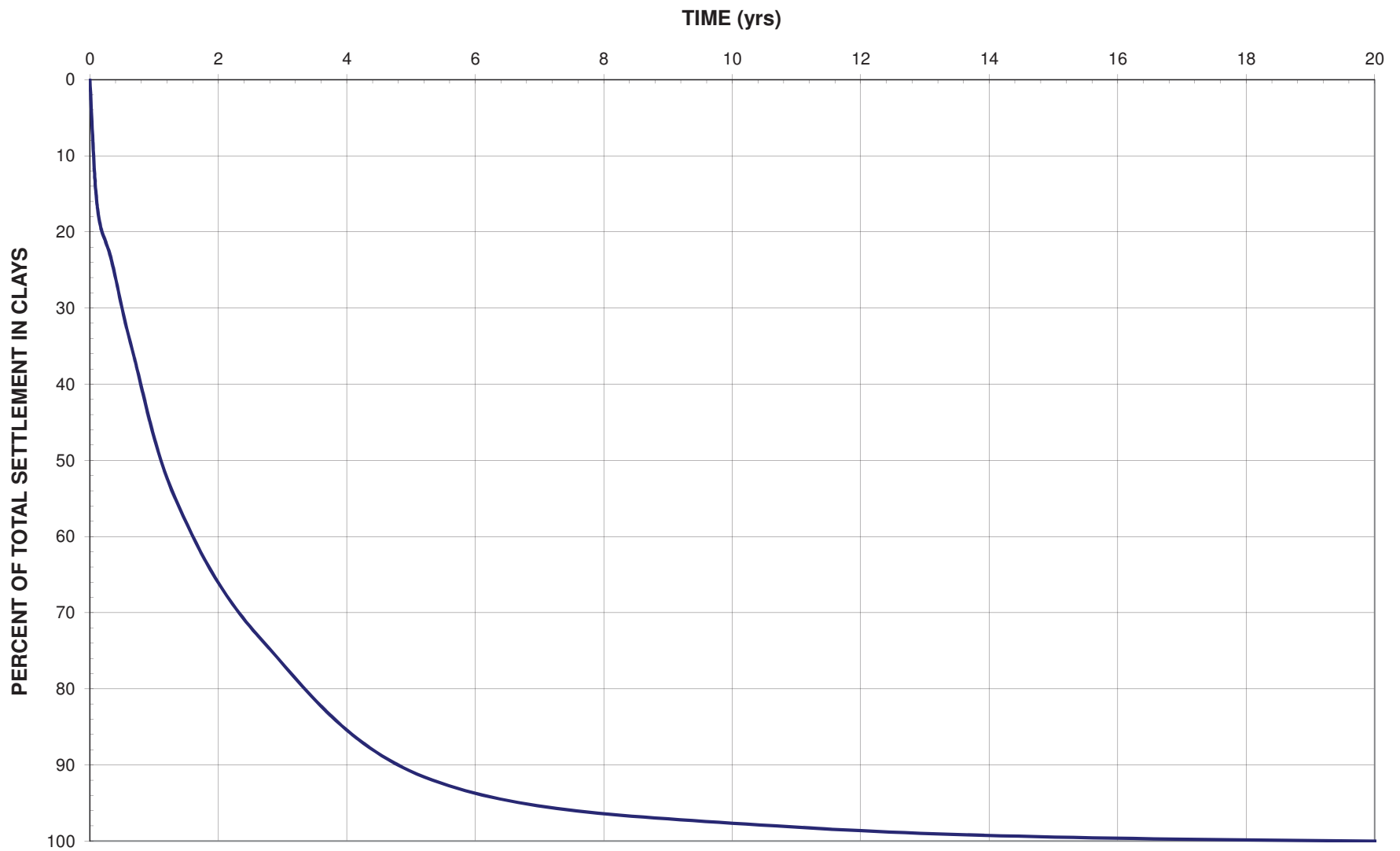




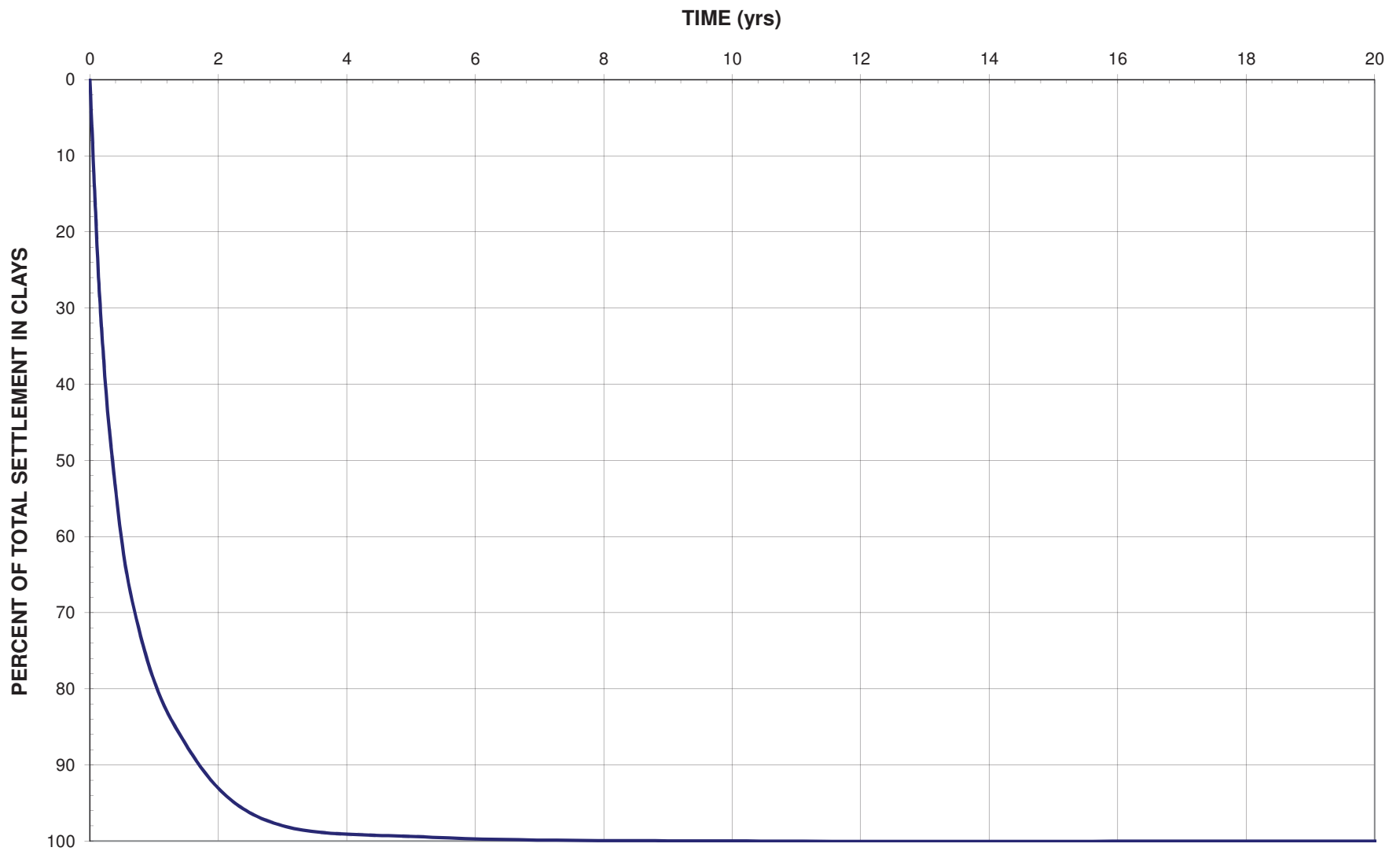




ESTIMATED TIME RATE OF CONSOLIDATION SETTLEMENT IN CLAYS
(Assuming 1-month of Tank Filling Period Starting at Time 0, Based on Boring B-1)



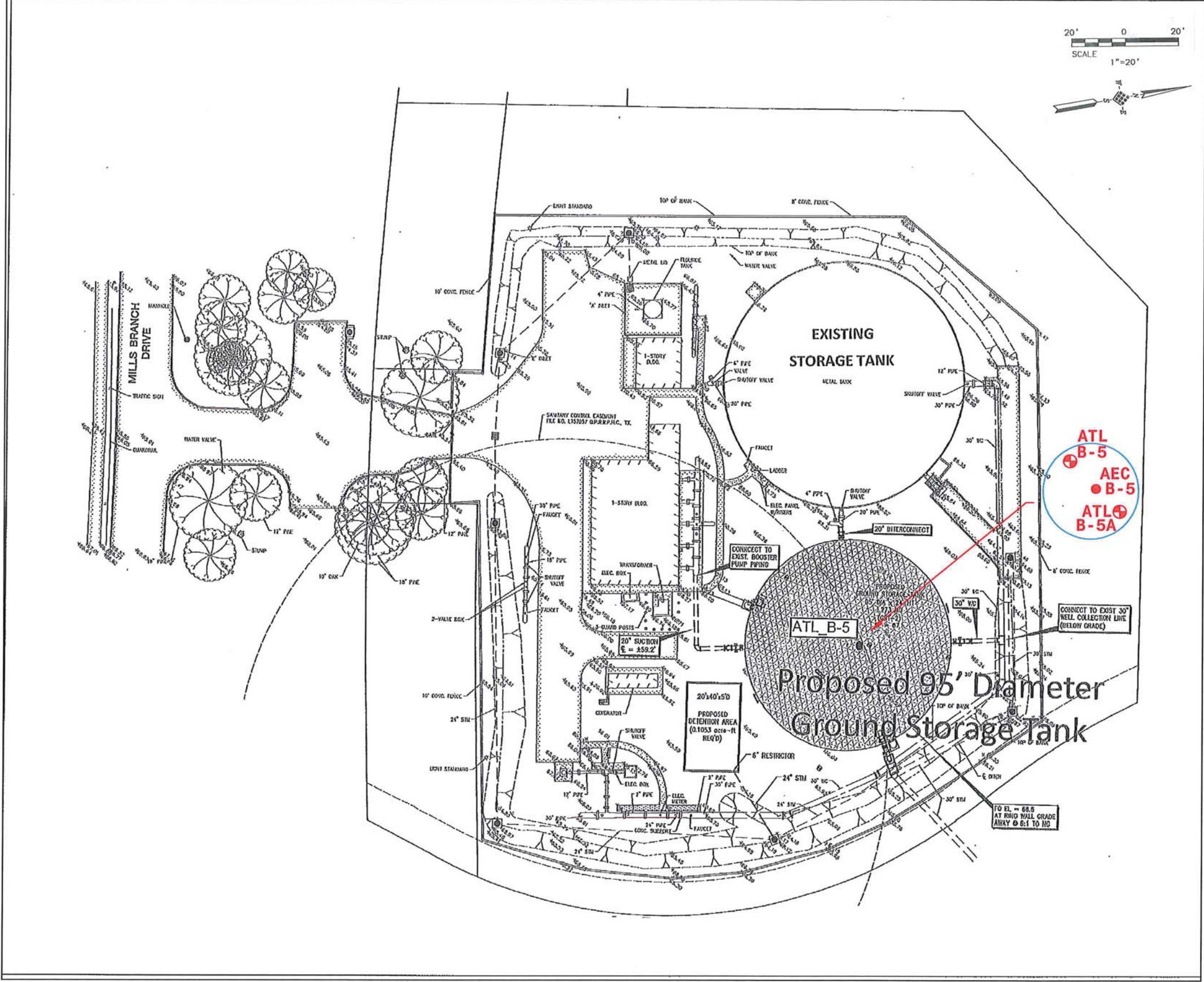
ESTIMATED TIME RATE OF CONSOLIDATION SETTLEMENT IN CLAYS
(Assuming 1-month of Tank Filling Period Starting at Time 0, Based on B-2, B-3, and B-4)





APPENDIX B

Plate B-1	Associated Testing Laboratories, Inc. Boring Location Plan, dated May 27, 2014, ATL Project No. G14-147
Plates B-2 and B-3	Associated Testing Laboratories, Inc. Boring Logs B-5 and B-5A, dated April 17 and 23, 2014, ATL Project No. G14-147



LOCATION OF BORINGS

NEW WATER STORAGE TANK AT
KINGWOOD WATER PLANT 3

Associated Testing Laboratories, Inc.
3143 Yellowstone Blvd. Houston, Texas
Tel: (713) 748-3717 Fax: (713) 748-3748

WBS NO.: S-000600-0044-3

PROJECT NO. G14-147

FIGURE. 2

Associated Testing Laboratories, Inc. 3143 Yellowstone Blvd Houston, Texas-77054				LOG OF BORING B-5										PAGE 1 OF 3		DATE 04/17/2014								
				PROJECT: New Water Storage Tank at Kingwood Water Plant 3 WBS No. S-000600-0044-3										SURFACE ELEVATION										
				PROJECT NO.: G14-147 BORING TYPE: Auger																				
DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	LOCATION		POCKET PENETROMETER (P, tsf)	BLOW COUNT (N, Blows/Foot)	N (blows/ft) 20 40 60 80 ▲ Q _u (tsf) ▲ 1.0 2.0 3.0 4.0 ★ DD (pcf) ★ 90 100 110 120 ◆ P (tsf) ◆ 1.0 2.0 3.0 4.0				DRY DENSITY (pcf)	Undrained Shear STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	Natural Moisture Content and Atterberg Limits			MOISTURE CONTENT (%)	ATTERBERG LIMITS (%)			PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°) OTHER TESTS & REMARKS
				Northing:	Easting:			Plastic Limit	Moisture Content	Liquid Limit	LL					PL	PI							
0				Water Plant 3		1.0												17	23	15	8	77		
				Northing:																				
				Easting:																				
				MATERIAL DESCRIPTION																				
0				Lean Clay with Sand (CL), firm, slight plasticity, light gray and tan (Fill up to 8 feet)		1.0																		
						1.0																		
						1.0																		
5		CL		..stiff below 6'		1.5																		
						1.5																		
						1.5																		
10				Fat Clay (CH), stiff, very high plasticity, light gray and tan		2.0																		
				..very stiff with ferrous nodules below 10'		3.0																		
						3.0																		
						3.5																		
15		CH		..with slickensided layers below 14'		3.5																		
				..stiff below 16'		3.75																		
						3.75																		
						3.75																		
						3.75																		
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Associated Testing Laboratories, Inc. 3143 Yellowstone Blvd Houston, Texas-77054				LOG OF BORING B-5										PAGE 3 OF 3		DATE 04/17/2014						
				PROJECT: New Water Storage Tank at Kingwood Water Plant 3 WBS No. S-000600-0044-3										SURFACE ELEVATION								
				PROJECT NO.: G14-147 BORING TYPE: Auger																		
DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	LOCATION		POCKET PENETROMETER (P, tsf)	BLOW COUNT (N, Blows/Foot)	N (blows/ft)		DRY DENSITY (pcf)	Undrained Shear STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	Natural Moisture Content and Atterberg Limits			MOISTURE CONTENT (%)	ATTERBERG LIMITS (%)			PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°) OTHER TESTS & REMARKS
				Northing:	Easting:			20	40					60	80	Plastic Limit		Moisture Content	Liquid Limit	LIQUID LIMIT		
								1.0	2.0	3.0	4.0							LL	PL	PI		
40				Water Plant 3		0.5							34				21	39	17	22	78	
				..soft below 39'																		
				..firm below 42'		1.0											21					
				..soft below 43'		0.5											19	25	15	10		
				..stiff below 44'		2.0											15					
45				..firm below 45'		1.5											17	29	15	14	46	
				Silty Sand (SM), loose, non plastic, light gray and tan (wet)			9										25				32	
				..very loose below 48'			3										25					
50				..very dense below 52'			1										24				36	
				..dense below 53'			64										21					
							42										19					
55																						
				..6" gravel layers at 58'																		
				Fat Clay (CH), very stiff, very high plasticity, light gray and tan		2.5	10										28	63	21	42	97	
Water Level Initial: 23' After Drilling 19' 24 Hrs: 19'				Key to Abbreviations: N - SPT Data (Blows/Ft) P - Pocket Penetrometer (tsf) T - Torvane (psf) Qu - Undrained Shear Strength (tsf) DD - Dry Density (pcf)				Notes: Augered Dry to 24'; Hole Caved at 19'; Hole Grouted after Drilling. Drilled By: Soltek, LLC , Logged BY: PV, Checked By: Jitu/John, QC/QA By: PST														
Sample Key: SPT Shelby Tube Disturbed																						

Associated Testing Laboratories, Inc. 3143 Yellowstone Blvd Houston, Texas-77054			LOG OF BORING B-5A										PAGE 1 OF 2 DATE <div style="text-align: right;">04/23/2014</div>													
			PROJECT: New Water Storage Tank at Kingwood Water Plant 3 WBS No. S-000600-0044-3										SURFACE ELEVATION													
			PROJECT NO.: G14-147 BORING TYPE: Auger																							
DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	LOCATION		POCKET	PENETROMETER (P, tsf)	BLOW COUNT (N, Blows/Foot)	● N (blows/ft) ● 20 40 60 80 ▲ Q _u (tsf) ▲ 1.0 2.0 3.0 4.0 ★ DD (pcf) ★ 90 100 110 120 ◆ P (tsf) ◆ 1.0 2.0 3.0 4.0				DRY DENSITY (pcf)	Undrained Shear STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	Natural Moisture Content and Atterberg Limits			MOISTURE CONTENT (%)	ATTERBERG LIMITS(%)			PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°) OTHER TESTS & REMARKS	
				MATERIAL DESCRIPTION					Plastic Limit Moisture Content Liquid Limit ┌───┴───┐ 20 40 60 80			LL					PL	PI								
0					Water Plant 3 Northing: Easting:																					
5																										
10		CL			Sandy Lean Clay (CL), tan																					
15																										
20		SM			Silty Sand (SM), dense, non plastic, light gray and tan			45											2						15	
22								34											3							
24		CH			Fat Clay (CH), very stiff, high plasticity, light gray and tan	2.5					92							30	83	24	59	96				
26																										
28		SM			Silty Sand (SM), medium dense, non plastic, light gray and tan																					
30																										
32																										
34		CH			Fat Clay (CH), very stiff, light gray and tan	3.0		11			93							25	87	25	62	17				
36																										

Water Level Initial: ▽ After Drilling ▽ 24 Hrs: ▽

Water Observations: Initial Water Level: 26.5', After Drilling Water Level: 23'

Sample Key: SPT Shelby Tube Disturbed

Key to Abbreviations:

N - SPT Data (Blows/Ft)

P - Pocket Penetrometer (tsf)

T - Torvane (psf)

Q_u - Undrained Shear Strength (tsf)

DD - Dry Density (pcf)

Notes:

Augered Dry to 28.5', Hole Caved at 23.5', Hole Grouted after Drilling. Drilled By: Soltek, LLC, Logged BY: PV, Checked By: Jitu/John, QC/QA By: PST

Associated Testing Laboratories, Inc. 3143 Yellowstone Blvd Houston, Texas-77054			LOG OF BORING B-5A										PAGE 2 OF 2		DATE 04/23/2014							
			PROJECT: New Water Storage Tank at Kingwood Water Plant 3 WBS No. S-000600-0044-3										SURFACE ELEVATION									
			PROJECT NO.: G14-147										BORING TYPE: Auger									
			LOCATION Water Plant 3 Northing: Easting:										MATERIAL DESCRIPTION									
DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	POCKET PENETROMETER (P, tsf)	BLOW COUNT (N, Blows/Foot)	N (blows/ft) 20 40 60 80	Q _u (tsf) 1.0 2.0 3.0 4.0	DD (pcf) 90 100 110 120	P (tsf) 1.0 2.0 3.0 4.0	DRY DENSITY (pcf)	Undrained Shear STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	Natural Moisture Content and Atterberg Limits			MOISTURE CONTENT (%)	ATTERBERG LIMITS (%)			ESTIMATED ANGLE OF INTERNAL FRICTION (°)	OTHER TESTS & REMARKS
													Plastic Limit Moisture Content Liquid Limit			LIQUID LIMIT PLASTIC LIMIT PLASTICITY INDEX			PASSING #200 SIEVE (%)			
													20 40 60 80			LL PL PI			20 40 60 80			
40																24	45	18	27	89		
	CL															21	31	16	15	36		
	SC															19	18	14	4	66		
45	ML															22						
																24				36		
50	SM															20	21	14	7	29		
																24				5		
55	SP SM															24						
																24						
60	CL SM															24	31	16	15	55		
																25				17		

Water Level Initial: ▽ After Drilling ▽ 24 Hrs: ▽

Water Observations: Initial Water Level: 26.5', After Drilling Water Level: 23'

Sample Key: ☒ SPT ☒ Shelby Tube ☒ Disturbed

Key to Abbreviations:

N - SPT Data (Blows/Ft)

P - Pocket Penetrometer (tsf)

T - Torvane (psf)

Q_u - Undrained Shear Strength (tsf)

DD - Dry Density (pcf)

Notes:

Augered Dry to 28.5', Hole Caved at 23.5', Hole Grouted after Drilling. Drilled By: Soltek, LLC, Logged BY: PV, Checked By: Jitu/John, QC/QA By: PST